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(March 1956)

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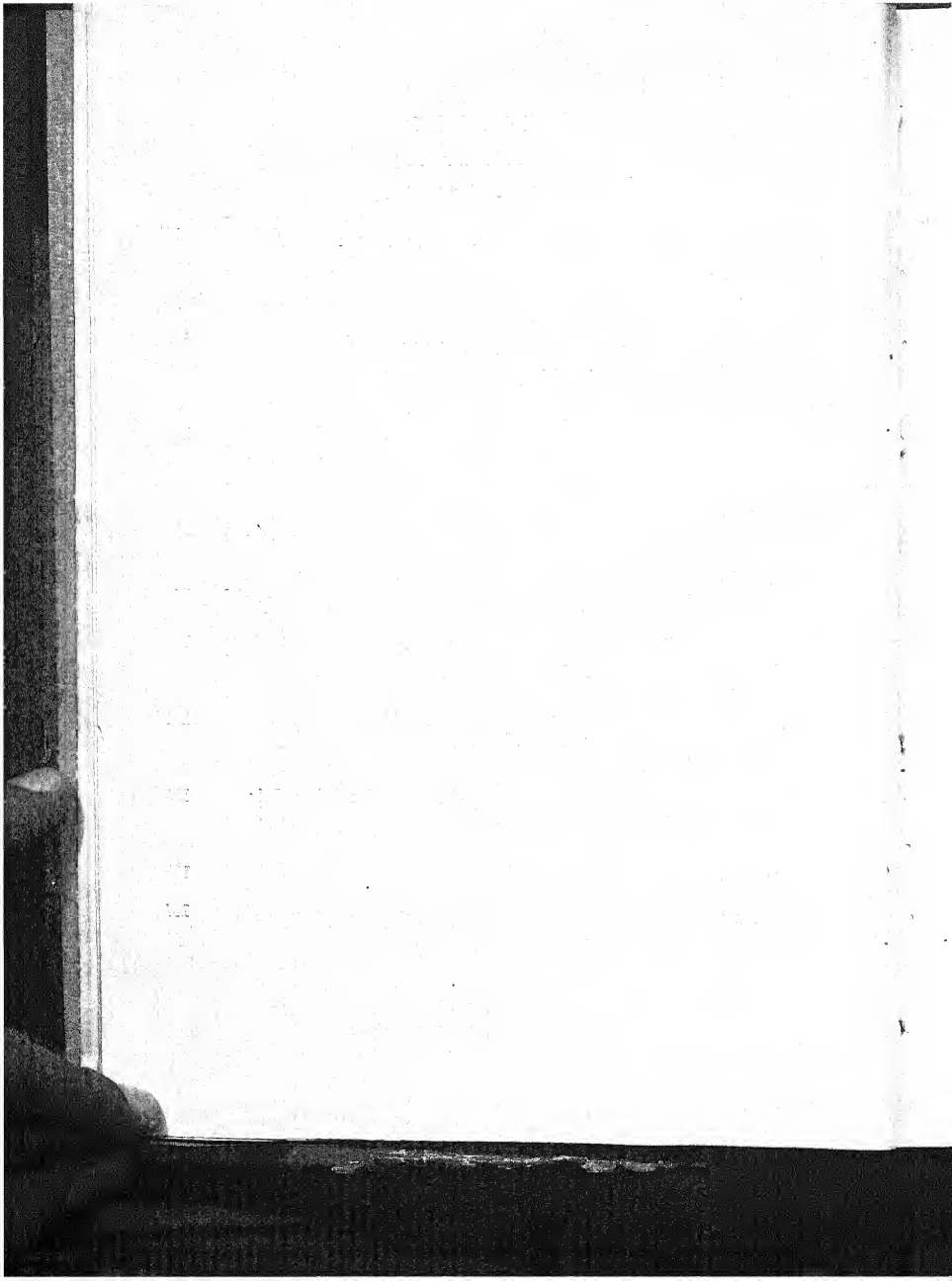
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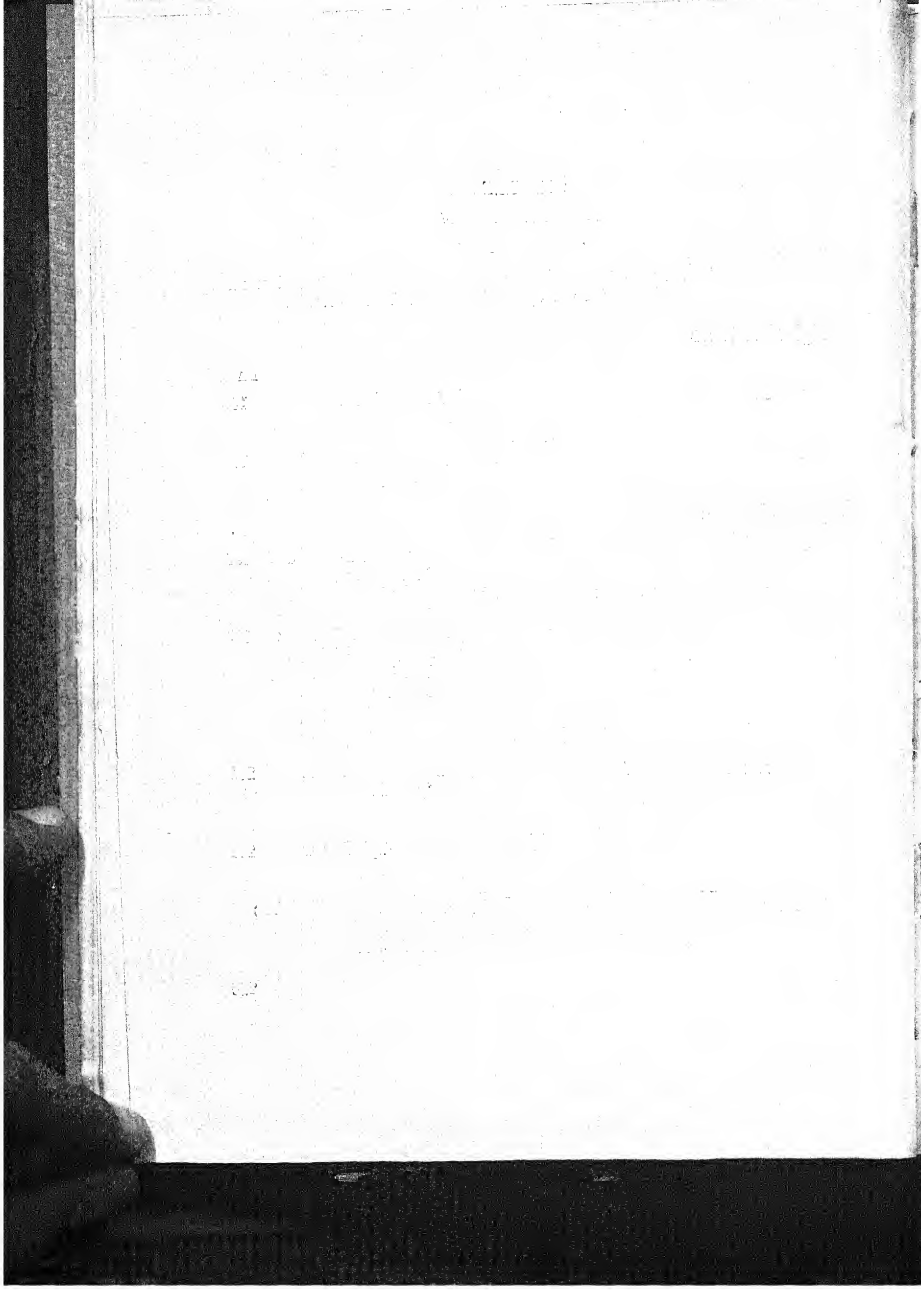


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ORIGINAL ARTICLES

ENZOOTIC BOVINE PARAPLEGIA IN SOME MALNAD TRACTS (HILLY AND HEAVY RAINFALL REGION) OF MYSORE STATE WITH PARTICULAR REFERENCE TO CEREBROSPINAL NEMATODIASIS AS ITS PROBABLE CAUSE*

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(Received for publication on February 18, 1955)

(With Plates I-IV and two text-figures)

PARAPLEGIA in domesticated animals has been observed and recorded in various parts of the world. Crawford [1939-42] recorded for the first time paraplegia among goats in Ceylon. Enzootic paralysis in sheep, goats and horses has been a problem of much investigation and research, which has engaged the special attention of Japanese workers in Korea and Japan. But the literature on the subject has remained somewhat obscure because of its publication in Japanese language. While bringing these publications to light, Innes [1951, 1952] has now stressed the need for search into a possible nematodal cause in obscure paralytic conditions of domestic animals. According to Innes [1951] the lesions, such as acute inflammation with myelin degeneration, faecal and perivascular cellular infiltration, microglial and astrocytic response, and in severely affected areas axis cylinders having irregularly globose or elongated swellings, and the process on the whole being a patchy, liquefactive, necrotising encephalomyelitis, have to be regarded as specific for cerebrospinal nematodiasis. McGaughey [1951] has reported cerebrospinal nematodiasis among goats with lumbar paralysis in Ceylon and has demonstrated nematode larvae in the nervous tissue of paraplegic goats. Innes, Shoho and Pillay [1952] have not only observed the specific histopathological lesions but also found immature nematodes in brain and spinal cord of paraplegic sheep and goats in Japan. Ishii, Yajima *et al.*, [1953] have experimentally produced lumbar paralysis in goats in Japan. They fed mosquitoes on the blood of an ox carrying microfilaria of *Setaria digitala* and after allowing 14 days for maturation, the infective larvae were dissected out from the mosquitoes and their suspension in saline inoculated hypodermically into experimental goats. They are of the opinion that cerebrospinal nematodiasis is the etiological factor of seasonal lumbar neuro-paralysis in sheep, goats and horses in Japan and Korea. Innes [1952] is of the view that paraplegia among animals, including Kumri in horses in India, may be due to some form of cerebrospinal nematodiasis and suggests the importance of detailed histopathological studies of brain and spinal cord in such cases. Innes [1953] has also studied the nervous system of a paralysed goat from Orissa (India) and observed microscopic patchy leptomeningitis with some perivascular cuffing and glial reaction. In his

*This investigation was carried out under the programme of the Veterinary Disease Investigation Scheme jointly sponsored by the Indian Council of Agricultural Research, New Delhi, and the Government of Mysore.

opinion the lesions of the paraplegic goat were not those of viral or bacterial encephalomyelitis but simulated the histopathological picture of proved cases of cerebrospinal nematodiasis, except that the nematode was not found. Shoho [1954] has reported that Pillai and Innes (unpublished work) recently have found malacic lesions associated with the nematode in the spinal cord of an equine paralytic case (Kumri) in Ceylon. Shoho [1952], Pillai and Perara [1953] have found Caricide (1-Diethyl carbamyl-4-Methyl piperazine citrate), a filaricidal drug, effective in cases of cerebrospinal nematodiasis of domestic animals.

Bush [1951] is of the view that mineral deficiencies play a very decisive role in producing paraplegia in animals, especially sub-normal or low serum phosphorus levels, and treatment with calcium, phosphorus and magnesium is said to have proved successful in curing more than 100 out of 244 cases of paraplegia in goats and sheep treated by him in Japan. His experiments to produce lumbar paralysis in sheep and goats with microfilaria of *Setaria digitata* are reported to have yielded negative results, when factors like mineral deficiencies were eliminated. In his opinion, therefore, lumbar paralysis in sheep, goats, cattle and horses may correctly be termed as nutritional paresis. Neelakanta Iyer and Seetharaman [1953] reported complete cure in five out of six cases of bovine paraplegia which they treated in South Kanara District with magnesium sulphate and calcium borogluconate. They are of the view that combined calcium and magnesium deficiency resulting in paraplegic symptoms in a large number of animals at one time in certain areas, might easily be mistaken for an outbreak of some infectious diseases. They contend that the onset of paraplegia might occur after the passing of minimal critical magnesium and calcium levels in the blood and in the ailing animals, magnesium and calcium content of blood might be within the normal range. Russell [1944] quoted Tufts and Greenberg's findings [1937-38] that symptoms of magnesium deficiency did not appear when serum magnesium was minimal. Green [1939] and Duckworth and Godden [1941] believed that the condition might be due to disturbance in endocrine mechanism concerned with the maintenance of serum magnesium level. McG Black [1954] reported that magnesium deficiency alone produced paralytic symptoms, coma and death in cattle.

BOVINE PARAPLEGIA IN MYSORE STATE

An obscure disease among cattle characterised by paraplegic or complete paralytic symptoms is prevalent in parts of Hosnagar, Sagar and Sorab taluqs of Shimoga district of Mysore State and in areas bordering south and north Kanara districts of Madras and Bombay States respectively. Bovine paralysis in south Kanara district, Madras State with identical symptoms and course was reported by Viswanathan [1946], Sastry [1948] and Ramakrishnan and Ananthapadmanabhan [1953] from Madras and a similar disease termed as "undiagnosed disease" among cattle and buffaloes of north Kanara district was reported by Kulkarni [1952] from Bombay State.

Enzootic bovine paraplegia, as observed and investigated in some Malnad tracts of Mysore State, appears to be regional in its distribution and seasonal in incidence. A marked increase in the number of outbreaks is generally observed during and after the monsoon rains from June to October. The endemic area of this obscure

nervous disease in Hosnagar, Sagar and Sorab taluks of Shimoga District forms part of the Western Ghats and is contiguous with south Kanara of Madras State and north Kanara of Bombay State, where a similar condition has been recorded. The area is characterised by dense forests and valleys with an average rainfall of over 150 inches annually. The valleys abound in strips of wet land which are more or less exclusively under paddy and arecanut cultivation. On the slopes surrounding the valleys are here and there small villages and hamlets and their cattle graze on adjoining hills and jungles. Except the working animals used for paddy cultivation, the rest of the cattle of this Malnad area are not fed on any concentrates or mineral supplement. Sheltering of animals at nights is peculiar to these parts and consists of their being huddled together without being tied or secured, inside an enclosed ill ventilated stall. Their bedding consists of dried or green leaves, depending on the seasons. The daily collection of dung and urine from the animals are allowed to get mixed up with the leaves and at intervals of a fortnight or so fresh layer of leaves is spread on the floor without removing the previous accumulation and this process continues till the onset of cultivation season, when the whole decayed matter is removed to the lands and used as manure. During the rainy season the animals lie down on such a type of bedding soaked in dung and urine and get severely exposed to dampness and moisture. In some parts of Sagar taluk the low lying pastures become water-logged due to continuous heavy rains and cattle seldom have access to any grass as it is practically submerged in water. During this period, they just subsist on whatever vegetation they can eat in the dense forests. In summer when pastures get dried up, animals have to feed on the leaves of trees and bushes. Consequently the condition of the animals in these parts is generally poor and their quality inferior. Heavy rainfall, dense forests and poor condition of the cattle are the outstanding features of the endemic area of this obscure disease while a variety of blood sucking insects are not uncommon in the locality.

This obscure nervous disease of bovines, characterised by paraplegia and progressive paralysis, prevalent in some parts of Shimoga, south Kanara and north Kanara districts of Mysore, Madras and Bombay States respectively has been attributed by different workers to different conditions at different times. Viswanathan [1946] in Madras suspected the disease to be bovine contagious pleuropneumonia. Ramakrishnan [1953] thought that the condition might be a form of Botulism, but failed to produce the disease in healthy animals by feeding them with emulsion of bones collected from affected areas. He quoted personal communications from Hurley [1949] and Rajagopalan [1950] instructing the departmental staff in Madras to eliminate the possibility of acute amphistomiasis, theileriasis and hydrocyanic acid poisoning and recorded that materials from a number of affected cattle with paraplegia, when chemically analysed, did not show any evidence of hydrocyanic acid poisoning.

Kulkarni [1952], while recording a similar disease in north Kanara district (Bombay State) thought that it might be pulmonary haemorrhagic septicaemia. Ramakrishnan and Ananthapadmanabhan [1953] suggested that the disease might be either latent trypanosomiasis or some form of cerebro-spinal microfilariasis, while Neelakanta Iyer and Seetharaman [1953] believed that the condition might

be some form of nutritional paresis caused by combined hypo-calcemia and hypomagnesemia.

SUSCEPTIBLE ANIMALS

From the observations made by the author in Hosnagar, Sagar and Sorab taluks of Shimoga district in Mysore State, only cattle were found to be affected. It may be because in the so-called endemic area of the disease in the State other species of ruminants are not usually reared excepting a few buffaloes for purposes of milk or work (wet cultivation) and these are generally well taken care of. Cattle of all ages were observed to suffer from the disease although the incidence was most common in adult animals.

Typical ailing cases were observed in the following villages where the disease broke out in 1954 :

1. Nittur	}	Hosnagar taluk
2. Ebagodu hamlet of Brahmanwada village		
3. Nithrabailu hamlet of Byse village		
4. Kalgadde		
5. Malali	}	Sagar taluk
6. Bardavalli		
7. Marthur		
8. Chanagonda		
9. Ambargodlu		
10. Hebse		
11. Kalgodu		
12. Tumari		

SYMPTOMS OF THE DISEASE

From the observations made on the symptoms and the course of the disease, three types or forms could be recognised, viz. (i) acute (ii) sub-acute and (iii) chronic. The disease in all the three forms was non-febrile. In acute cases, the onset of paralysis of the entire body was somewhat sudden and the course of the disease extended only to about 48 to 72 hours and in a few cases death occurred within 12 hours. Such cases were regarded as peracute type. The chief symptoms characterising the acute form were sudden signs of shivering, unsteadiness of the limbs, staggering gait, animal lying down with its head turned to one side resembling the characteristic posture of animals suffering from milk fever complex, profuse salivation, paralysis of the tongue and its protrusion to one side, hard breathing, finally prostration, convulsions and death. In subacute cases the disease was characterised by the onset of paraplegia symptoms and in chronic cases, of immobility of tail followed by paraplegia. However, in both forms gradual progressive paralysis of the entire body was the ultimate result. Such animals were observed to lie down frequently while grazing, due probably to weakness of hind quarters, although their apparently healthy looks did not show their illness, and they also continued to feed normally. The course of the disease in subacute form extended up to a week or so, while in chronic form it ran up to a month or even more. The ailing animal

had no control over the tail, which appeared to hang loose, there being no attempt at swishing at any time. The response to pin pricks on the tail was either very slow or imperceptible. In the beginning micturition was normal but latter on frequency of micturition increased and urine was passed in drops with some strain. This was followed by a gradual onset of anterior paralysis, involving the muscles of the tongue resulting in an involuntary flow of saliva. The neck was bent to one side and tongue protruded out.

Mortality. In acute cases the mortality was almost 100 per cent, while in subacute and chronic forms recovery was rare and if any, it was mostly in chronic cases.

Post-mortem lesions. Detailed post-mortem examinations were conducted on 4 typical cases in the field. In three cases post-mortem was done within 3 hours after death and in one about after 12 hours. Two of the four cases had acute course of the disease extending not more than 3 days, while the other two cases had subacute course extending up to a week. In the two acute cases where the disease was characterised by complete paralysis of the body, the brain and spinal cord were slightly congested and softened and in the other two subacute cases which had only paraplegia, no microscopic lesions were evident.

In two cases congestion of small intestines and haemorrhagic patches on epicardium and endo-cardium were observed, while in one case heavy infestation of paramphistomes in the rumen was noticed.

METHODS AND MATERIAL

During the period of investigation which lasted for about two years (1952-1954), the following materials were obtained from typical cases for examination :

- | | |
|---|---|
| 1. Blood smears (from peripheral veins) | 32 ailing cases (microscopical examination) |
| 2. Heart blood, spleen and liver impression smears | 12 carcasses (microscopical examination) |
| 3. Cerebro-spinal fluid | 8 fresh carcasses (microscopic as well as cultural examination) |
| 4. Heart blood and spleen cultures | 4 fresh carcasses (cultural examination) |
| 5. Blood samples (defibrinated) | 4 ailing cases (biological test) |
| 6. Blood samples (citrated) | 2 ailing cases (chemical analysis) |
| 7. Serum samples | 10 ailing cases (chemical analysis and chemical test for surra) |
| 8. Lumbar portion of spinal cord and brain (half in glycerine and half in 10 per cent formalin) | 4 carcasses (biological test and histopathological examination) |
| 9. Pieces of lungs, liver, spleen, heart and kidneys | 4 carcasses (Histopathological examination) |
| 10. Blood sucking flies of cattle collected from endemic areas | 6 for entomological study |

EXPERIMENTS CONDUCTED

1. *Biological tests*

- (a) Two ailing cattle with typical symptoms of paraplegia at Ebagodu hamlet of Nagar area, reported to be ailing for three days were selected and were bled from the jugular vein and immediately the blood was injected intraperitoneally in 2 c.c. doses to 2 guineapigs and 2 rabbits and the animals were kept under observation for 5 weeks examining their blood smears every day, to study the possibility of latent trypanosomiasis.
- (b) Similarly blood was drawn from two typical cases of bovine paraplegia in a sterile flask with glass beads and was defibrinated by constant shaking. Two bull calves were injected with the defibrinated blood at 15 c.c. intravenously and the animals were kept under observation for a month with a view to finding out if there was any infective agent in the blood.
- (c) Lumbar portion of spinal cord and brain were collected aseptically in sterile glycerine from two typical cases of bovine paraplegia soon after the death of the animals. Emulsions of the spinal cords were prepared in sterile water and 20 c.c. of emulsion injected subcutaneously into two bull calves, 5 c.c. of emulsion injected intraperitoneally into two rabbits and 0.2 c.c. intracranially into two guineapigs. All these experimental animals were kept under observation for a month to study the possibility of virus being an etiological factor.

Besides, lumbar portion of the spinal cord from a typical acute case was sent in 50 per cent glycerine to I. V. R. I., Mukteswar, for biological transmission experiments.

2. *Chemical analysis*

- (a) Ten serum samples collected from typical ailing cases of bovine paraplegia were analysed chemically for calcium, magnesium and phosphorus contents.
 - (b) Two citrated blood samples collected from typical cases of paraplegia were tested for copper deficiency.
- (3) *Chemical test for surra*

Ten serum samples collected from 10 typical ailing cases of bovine paraplegia were subjected to stilbamidine test as recommended by Ray [1950].

(4) *Histopathological examination*

Lung, liver, spleen, heart, kidney, brain and lumbar portion of spinal cord from 4 typical cases of bovine paraplegia were collected in 10 per cent formalin and paraffin sections were prepared. Histological sections of lung, liver and spleen, heart and kidney tissues were stained with haematoxylin and eosin and with Castroviejo's trichrome stain. The spinal cord and brain from two acute cases and the lumbar portion of spinal cord from two subacute cases were collected in 10 per cent formalin. After 48 hours of preservation, the tissues were taken out for

embedding and sectioning and the formalin solution which had become turbid was centrifuged. The sediment was examined carefully for larval forms of nematodes as suggested by Niimi (quoted by Innes [1953]) who thought that in some cases the nematodes may drop off the nervous system after the brain and spinal cord are placed in the fixative. A few pieces of softened portion of the spinal cord and brain were also emulsified in sterile water and thick smears were prepared and stained with haemotoxylin and eosin and giemsa's stains for microscopic examination.

Protocols

Case No. 1. A cow about 5 years of age belonging to Ebagodu hamlet of Nagar hobli of Hosnagar taluk, Shimoga district, Mysore State. Symptoms of paraplegia observed on 28th May 1954. Complete paralysis of all the four limbs, neck bent to one side, course was acute, death occurred on 30th May 1954. Brain and spinal cord removed soon after the death of animal.

Case No. 2. A cow of about 6 years of age belonging to Ebagodu hamlet of Nagar hobli, Hosnagar taluk, Shimoga district, Mysore State. Symptoms of immobility of tail observed on 21st June 1954 and complete paraplegia was observed on 25th June 1954, course was subacute, animal died on 27th June 1954. The lumbar portion of the spinal cord was removed one hour after the death of the animal.

Case No. 3. A cow belonging to Sirur village of Sagar taluk, Shimoga district, Mysore State. Typical symptoms of paraplegia were observed on 29th June 1954. Course was subacute, animal died on 5th July 1954. Spinal cord was removed about 12 hours after death of the animal.

Case No. 4. A cow of about 6 years of age belonging to Ambargodlu village of Sagar taluk, Shimoga district, Mysore State. Onset of complete paralysis of all the four limbs was sudden when observed on 25th August 1954. The disease had acute course and the animal died on 28th August 1954 (within three days). Brain and spinal cord were removed about three hours after the death of the animal.

RESULTS

Microscopic examinations

Blood smears from 32 typical ailing cases in different stages of the disease from 10 villages of Hosnagar and Sagar taluks were examined microscopically, but none of the smears revealed any specific bacterial or protozoan organisms. Heart blood and spleen impression smears from 12 cases and cerebro-spinal fluid smears from 8 cases collected within 6 to 8 hours after the death of the animals were also found negative, except the heart blood smears from one case which revealed numerous sarcocystis spores. Detailed microscopic examination of the nervous tissue sediment obtained after centrifugation of the fixative which contained the spinal cord and brain of two acute cases (Case No. 1 and 4) revealed three complete nematode larvae (Plate I, Fig. 1 and Text Fig. 1-A and Fig. 2-A, D) and in about 25 thick smears made from the emulsion of the spinal cord, two complete larvae (Plate I, Fig. 2 and Text Fig. 2-A and B.) and four incomplete larvae (Fig. 2-C, E, F and G.) were revealed by a few smears. All these larvae were sheathed. Of the five complete larvae the largest one

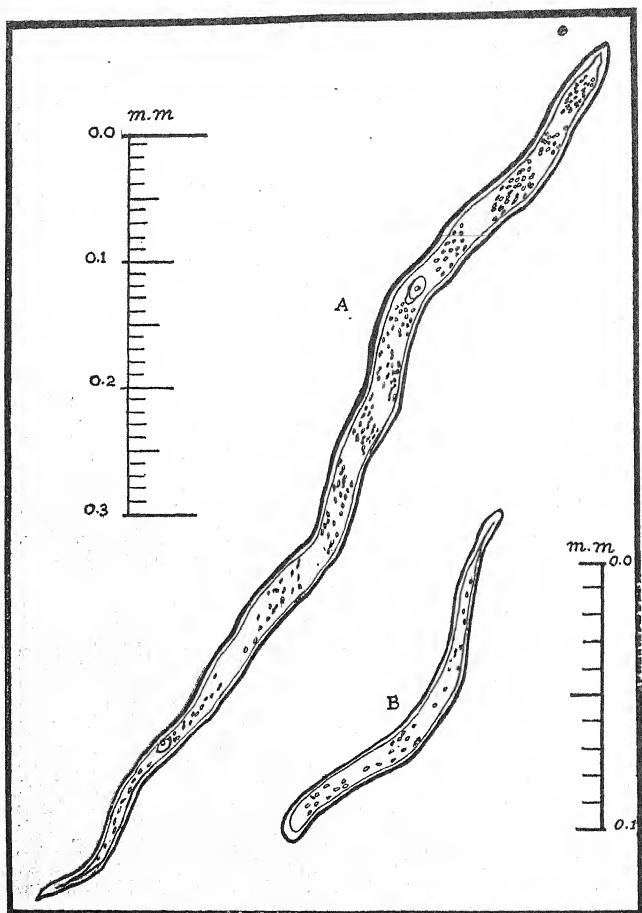


FIG. 1. 0.1 m.m.=100 microns

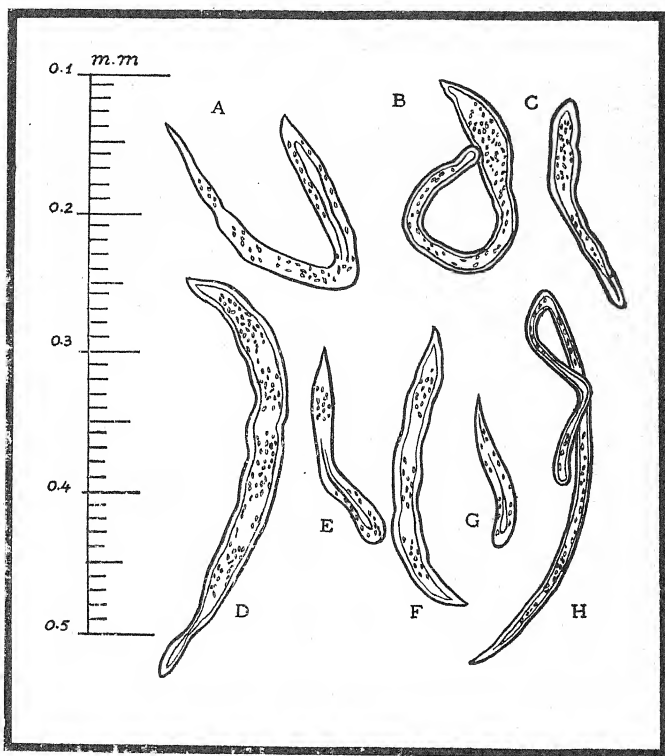


FIG. 2.

measured 810 microns in length and 24 microns thick at the head end and 28 microns in the middle (Plate I, Fig. 1, and Text Fig. 1, A). Other complete larvae measured 340 microns in length (Fig. 2, D), 310 microns (Fig. 2, B), 320 microns (Fig. 2, A) and 450 microns (Fig. 2, H).

Result of cultural examination

Cultures of heart blood, spleen and cerebro-spinal fluid from four typical cases did not reveal any bacterial growth on agar, blood agar, broth and Robertson media even after 72 hours of incubation.

Results of biological tests

Samples of defibrinated blood obtained from typical cases of bovine paraplegia, when injected subcutaneously and intravenously into bull calves did not produce the disease during a period of one month's observation and thus the possibility of a transmissible infective agent in the blood was eliminated. Emulsions of fresh spinal cord when injected into bull calves, rabbits and guineapigs subcutaneously, intraperitoneally and intra-cranially respectively, failed to produce the disease in the experimental animals.

Blood, cerebro-spinal fluid and emulsions of brain and spinal cord obtained from typical cases of bovine paraplegia on cultural and biological tests were found negative for bacteria, virus and protozoa and the disease was non-transmissible to buffalo-calves and laboratory animals. This was confirmed by the results received from the Indian Veterinary Research Institute, Mukteswar, where biological tests with the spinal cord were conducted in laboratory animals.

Blood smears of guineapigs and rabbits injected intraperitoneally with fresh blood from typical cases of bovine paraplegia were found negative for Trypanosomes for a period of five weeks and hence the possibility of latent trypanosomiasis was also ruled out.

Results of chemical test for surra

Nine out of 10 samples of sera obtained from typical cases when subjected to stilbamidine test (M. & B. 744) yielded negative results, while one serum sample which was considerably haemolysed showed doubtful reaction.

Results of chemical analysis

Calcium, magnesium and phosphorus contents of serum samples from 10 ailing cases are given in Table I. Serum calcium level in 9 cases was within the normal range and in one case it was considerably low, while serum magnesium level was slightly below the normal range in six cases and normal in four cases. (The slight low serum magnesium level is subject to correction since there is no established data regarding the normal range of serum magnesium level in local cattle of the Malnad tracts). The serum phosphorus level in all the 10 cases was within the normal range.

Results of entomological study

The blood sucking flies collected from the area were of the two types, one large and the other small and by their mouth parts were found to belong to the family Tabanidae and genus Tabanus.

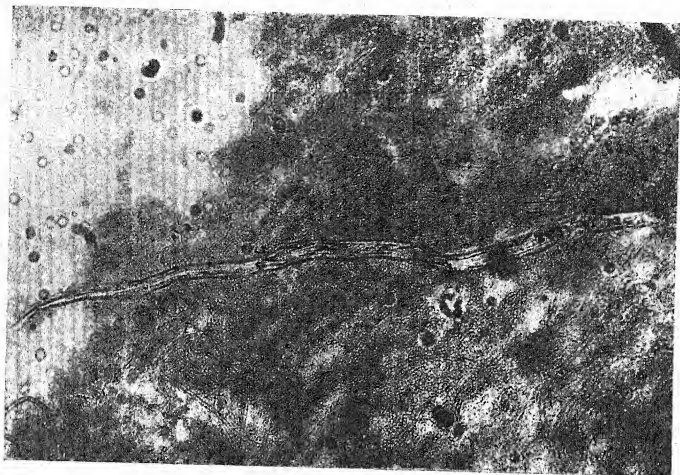


FIG. 1. Nematode larva found in the spinal cord of a cow, acute case of bovine paraplegia (larva found in the tissue sediment got by centrifugation of the fixative fluid which contained the lumbar portion of the spinal cord of Case No. 1).

.....H.E. X100

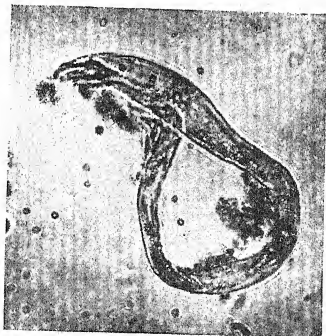


FIG. 2. Complete larva of nematode spinal cord of a cow (larva found in the smears of lumbar portion of spinal cord of the Case No. 4). Note the sheath distinctly visible

.....H.E. X500

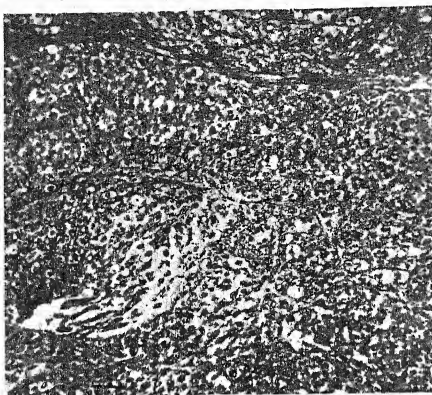


FIG. 1. Spinal cord, bovine paraplegia, cow (Case No. 2) showing malacic lesions in the white matter with microcavitation.

.....H.E. X 105



FIG. 2. Spinal cord, bovine paralysis, cow (Case No. 4) showing acute liquefaction and a prominent vessel with thickened walls due to denser reticulum.

.....H.E. X 350

TABLE I
Calcium, magnesium and phosphorus contents of serum samples from ten ailing cases

Description of animals	Duration of the disease	Calcium content in milligrams per 100 c.c. serum	Magnesium content in mgm. per 100 c.c. serum	Phosphorus content in mgm. per 100 c.c. serum
(1) Red bull calf from Nagar area (Ebagodu village)	6 days (subacute case with paraplegia)	14.4	2.22	7.52
(2) Black cow from Nagar area (Byse village)	30 hours after the disease and 12 hours before death (acute case with complete paralysis)	5.2	6.52	8.45
(3) Reddish grey cow from Sagar area (Baradavalli village)	5th day (subacute with paraplegia only)	9.8	3.19	7.83
(4) Black cow from Sagar area (Baradavalli village)	2 days (acute case with complete paralysis)	10.4	3.7	6.92
(5) Cow from Sagar area (Kosgodu village)	6 days (subacute case with paralysis)	10.00	1.75	8.42
(6) Heifer from Sagar area (Kosgodu village)	5 days (subacute case with paraplegia)	19.40	1.82	7.02
(7) Cow from Sagar area (Ambargodu village)	3 days (subacute case with paraplegia)	10.20	1.81	8.51
(8) Bullock from Sagar area (Channagonda village)	2 days (acute case with complete paralysis)	9.80	[1.57]	6.54
(9) Cow from Sagar area (Karigodu village)	3 days (subacute case)	7.6	0.88	6.05
(10) Bullock from Sagar area (Tumari village)	3 days (subacute case)	8.0	1.33	7.82

Treatment with calcium and magnesium salts

The line of treatment followed was subcutaneous injections of 100 c.c. of 20 per cent magnesium sulphate solution and 40 c.c. of 25 per cent calcium borogluconate solution each day for 3 or 4 consecutive days injected subcutaneously. The results are given in Table II. Six chronic and subacute cases gradually improved and recovered, while five acute and subacute cases died without any signs of improvement after treatment.

Histopathological examination

Sections of liver, spleen, kidney and heart revealed normal histological features, while sections of lungs from two cases had slight congestion and in other two cases the lungs were normal. However in none of the four cases, lungs had any indication of pleuropneumonia.

Histopathology

In one of the four animals (Case No. 3), sections of spinal cord did not reveal any characteristic histopathological features, while the sections of brain and spinal cord of the other three cases (Case No. 1, 2 and 4) had the following lesions. The white matter of the spinal cord was chiefly involved although the grey matter was also affected to a lesser extent. The lesion was one of acute softening, in which there was not only the myelin degeneration but also the ground substance was loosened and destroyed, resulting in a *status spongiosus* which was an impending factor in the preparation of intact paraffin sections (Plate IV, Fig. 1). In spite of good fixation of the brain and spinal cord, removed immediately after the death, this defect could not be improved. The most distinctive histological feature was the presence of numerous radially disposed vessels with prominent thickened walls due to denser reticulum (Plate II, Fig. 2) lying in disorderly cracks and crevices. Focal cellular infiltration, liquefaction and microcavitation were observed in all the three cases (Plate II, Fig. 1 and 2). Definite changes in axis cylinders were constantly present. Swollen scanty axis cylinders, distorted and irregularly globose, within the transversely cut tube representing myelin sheath were seen in haematoxylin eosin stained sections. Perhaps, many of the empty round spaces seen in the paraffin sections might be the result of the falling out of such irregularly globose bodies contained in those spaces (Plate IV, Fig. 2). On the whole the histological picture of the spinal cord in all the three cases resembled the lesions of *focal liquefactive encephalomyelomalacia* as described by Innes [1951] and stated to be the only diagnostic feature of cerebro-spinal nematodiasis. The most important finding of the histological study besides the microscopic lesions already described was the detection of sections of immature nematodes (Plate III, Fig. 1 and 2) in the lumbar portion of the spinal cord of two cases (Case No. 1 and 4). The nematode observed in the sections of the tissues appeared more developed than those in the preservative fluid (Plate III, Fig. 1).

DISCUSSION AND CONCLUSION

The bovine paraplegia and paralysis observed in Hosnagar and Sagar taluks of Shimoga district of Mysore State in its nature, course and symptoms appeared to be identical with the so-called "Hidden disease" of south Kanara district in

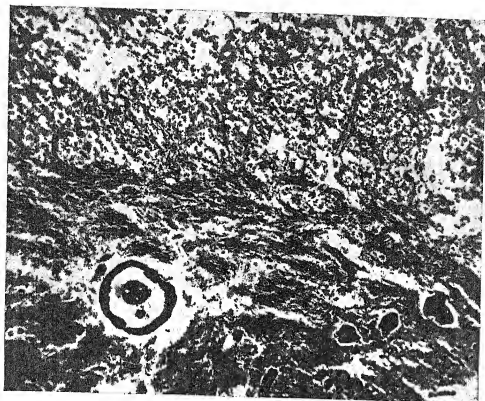


FIG. 1. Spinal cord, bovine paralysis, cow (Case No. 4) showing malacic lesion with a transverse section of an immature nematode. Note the oesophagus of the worm with a distinct triradiate lumen.

.....H.E. X120

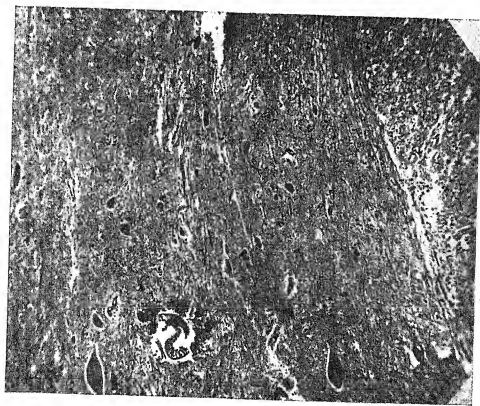


FIG. 2. Spinal cord, bovine paralysis, cow (Case No. 1). Note the right upper margin showing small area of liquefaction and microcavitation in the white matter, note also in the left lower corner, a section of the immature nematode.

.....H.E. X90

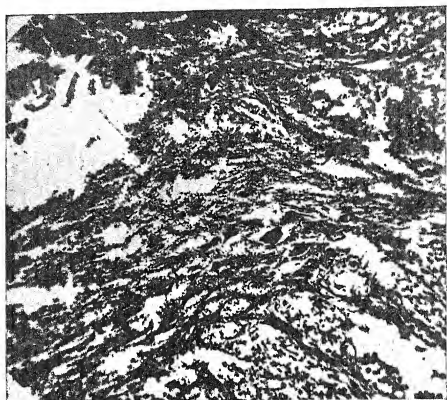


FIG. 1. Spinal cord, bovine paraplegia, cow (Case No. 2) showing not only myelin degeneration but also destroyed ground substance.
.....H.E. X 92

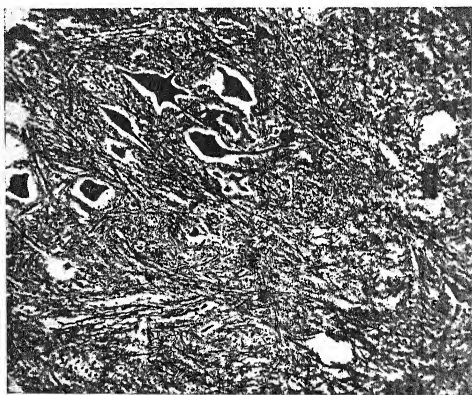


FIG. 2. Spinal cord, bovine paraplegia, cow (Case No. 2) showing empty spaces as a result of the falling out of swollen axis cylinders. (Note giant neurones also.)
.....H.E. X 120

TABLE II
Results of subcutaneous injections with calcium and magnesium salts

Description	Duration of disease and symptoms	Period of treatment	Results
1. A black cow aged 6 years from Nagar area (Ebogodu hamlet)	Reported to be sick for 3 days, animal had complete paraplegia, animal dull, off feed	1st injection on 29.5.54 2nd injection on 30.5.54	No improvement and animal died
2. A red bull calf 1½ years old from Nagar area (Ebogodu hamlet)	Reported to be ailing for 6 days, animal had complete immobility of tail but slight paraplegia, animal active and feeding normal	1st injection on 29.5.54 2nd injection on 30.5.54 3rd injection on 1.6.54	Animal recovered
3. A grey cow of 5 years age from Nagar area (Ebogodu hamlet)	Reported to be sick for 3 days with immobility of tail and paraplegia, animal active and feeding normal	1st injection (M. F. C.) on 28.5.54 2nd injection on 29.5.54 3rd injection on 30.5.54	Considerable improvement and finally recovered
4. A grey bull calf of 2 years age from Nagar area (Ebogodu hamlet)	Reported to be ailing for 24 hours with slight immobility of tail and staggering gait but no paraplegia, feeding normal, animal active	1st injection on 28.6.54 2nd injection on 29.6.54 3rd injection on 30.6.54	Gradual improvement and finally recovered
5. A red heifer of 3 years age from Nagar area (Nithureddi hamlet)	Reported to be sick for 6 hours with immobility of tail and staggering gait, animal active, feeding normal	1st injection on 29.6.54 2nd injection on 30.6.54 3rd injection on 1.7.54	Gradual improvement and finally recovered
6. A black cow of 5 years age from Sugar area (Bardavalli village)	Reported to be ailing for 4 days with complete paraplegia and paralysis of the entire body and sub-normal temperature, animal dull and comatose	1st injection on 30.6.54 2nd injection on 1.7.54 3rd injection on 2.7.54	No improvement observed, animal died

TABLE II—*contd.*
Results of subcutaneous injections with calcium and magnesium salts

Description	Duration of disease and symptoms	Period of treatment	Results
7. A grey cow of 6 years age from Sagar area (Bardavalli village)	Reported to be sick for 24 hours with complete paralysis of the whole body, animal dull, rumination suspended	1st injection on 4.7.54 2nd injection on 5.7.54	No improvement, animal died on the 2nd day
8. A black cow of 5 years age from Hosnagar area (Malali village)	Reported to be sick for 3 days with slight paraplegia and immobility of tail, feeding normal	1st injection on 17.7.54 2nd injection on 18.7.54 3rd injection on 19.7.54	Animal recovered
9. A grey bullock of 6 years age from Hosnagar area (Nittur village)	Reported to be ailing for a week with immobility of tail and weak hind quarters, feeding normal	1st injection on 23.7.54 2nd injection on 24.7.54 3rd injection on 25.7.54	Gradually improved and finally recovered
10. A black cow of 5 years age from Sagar area (Ambargodlu village)	Reported to be ailing for 2 days with immobility of tail and slight paraplegia, animal active, feeding normal	1st injection on 28.8.54 2nd injection on 29.8.54 3rd injection on 30.8.54	No improvement, animal died
11. A grey bull calf, 1½ years old, from Sagar area (Channagonda village)	Reported to be ailing for 3 days with immobility of tail and staggering gait, animal active, feeding normal	1st injection on 7.9.54 2nd injection on 8.9.54 3rd injection on 9.9.54	No improvement, animal died

Madras State and the "undiagnosed disease" of cattle of north Kanara district, Bombay State. The regional and seasonal conditions of these contiguous tracts of Mysore, Madras and Bombay States being almost identical, the animals of these hilly and heavy rainfall tracts are subjected to the same environmental conditions. The observations made so far in Mysore State and those reported from Madras and Bombay States regarding bovine paraplegia indicate that the obscure disease of cattle in the contiguous areas of all the three States may be one and the same and, therefore, the endemic zone for this disease could be demarcated as comprising contiguous areas of Shimoga, south Kanara and north Kanara districts of Mysore, Madras and Bombay States respectively.

DIFFERENTIAL DIAGNOSIS

Haemorrhagic septicaemia: All cases of bovine paraplegia studied in Mysore had an afebrile course and no lesions in the lungs were observed. Microscopic and cultural examination of heart blood collected from four typical cases immediately after death of the animals were found negative for pasteurilla organisms. Besides, blood drawn from a typical case only a few hours before death was injected into a rabbit which remained unaffected for 3 weeks during which it was kept under observation after injection. Haemorrhagic septicaemia in whatever form it might be, being a septicæmic disease, its casual organisms could neither escape detection in heart blood cultures made soon after the death of the animals nor in the rabbit inoculation test with the blood from a typical case drawn just a few hours before death.

Contagious bovine pleuro-pneumonia

Post-mortem examination of four typical cases of bovine paraplegia did not reveal any pneumonic lesions in the lungs. Sections of lung tissue were normal in histological features except for slight congestion. In two cases much laboured breathing was observed just before death suggesting some lung lesions, but on post-mortem examination lungs were found perfectly normal. The symptoms of respiratory distress observed appeared to be due to paralysis of diaphragm and other respiratory muscles rather than to pneumonic lesions in the lungs.

Acute theileriasis and anaplasmosis

Bovine paraplegia was always a non-febrile condition whether it was acute, where the onset of paralysis was sudden, or subacute and chronic. Such an afebrile condition could not be associated with the infection of blood protozoan parasites like piroplasms. Besides, peripheral blood smears taken just before death and heart blood smears taken soon after death did not reveal either Theileria or Anaplasma like bodies in red blood corpuscles and Koch's blue bodies in spleen in spite of detailed microscopic examination. Thus the possibility of this obscure disease being either the pulmonary form of haemorrhagic septicaemia or contagious bovine pleuro-pneumonia or acute theileriasis or anaplasmosis was definitely ruled out by systematic investigation.

Latent trypanosomiasis

Trypanosomes in bovines may not appear in peripheral circulation and hence may not be detected by examination of blood smears only, as the parasites get into deeper tissues like cerebrospinal and reticulo-endothelial systems. To eliminate

the possibility of latent trypanosomiasis not only blood smears from 32 ailing cases were examined in detail for the presence of trypanosomes, but also smears made from 8 samples of cerebrospinal fluid after centrifugation were examined. None of these revealed any indication of trypanosomes. Besides, 10 samples of serum from typical ailing cases were subjected to stilbamidine test (chemical test for surra) and all were found negative, except one which developed doubtful reaction.

Blood from two typical ailing cases of paraplegia was drawn and immediately injected into guineapigs and rabbits intraperitoneally. These guineapigs were maintained for more than a month and their blood smears were examined every day for trypanosomes with negative results. Thus all tests, viz. microscopic biological and chemical, for detection of trypanosomiasis having yielded negative results definitely ruled out the possibility of latent trypanosomiasis.

Virus etiology of the disease

Virus, as the probable etiological factor, was sometimes thought of in connection with this obscure disease. During the investigation the disease could not be produced experimentally in bull calves, rabbits and guineapigs by injecting fresh blood and emulsions of brain and spinal cord from typical cases of paraplegia indicating that the causal agent if it was virus, was not present in blood or brain and spinal cord of the affected animals. Although many animals died of the disease at one time in the same place, observations made in the field did not indicate that the disease was infectious in nature, tending to spread from one animal to another by contact.

The epidemiological features of the disease were highly suggestive of some insect vector playing some role in transmitting the disease. Two varieties of blood sucking flies one fairly large sized and the other small, were examined and found to belong to the genus—*Tabanus*. Whether these flies or other insects played any role in transmitting the disease from one animal to another cannot be asserted at this stage as the investigation on all aspects of the disease is not yet complete.

Hypo-calcaemia and hypomagnesiemia

During the investigation of this disease in Mysore State 11 cases (3 acute and 8 subacute) were treated with calcium borogluconate and magnesium sulphate in Nagar and Sagar areas during the months of May, June, July, August and September 1954. Of the 11 typical cases of bovine paraplegia treated, 6 subacute and chronic cases improved and gradually recovered, while the five acute and subacute cases did not improve and died even after treatment. Nine out of 10 serum samples from 10 ailing cases on chemical analysis did not reveal any calcium deficiency and only one had low calcium level. Serum magnesium level was within normal range in 4 cases and slightly low in the remaining six cases. There was no indication of phosphorus deficiency in any of the 10 cases. The beneficial effect of calcium and magnesium in 6 out of 11 cases and insignificantly low magnesium level in blood of 6 out of 10 cases studied seem to suggest that if at all any mineral deficiency had some bearing on precipitating the course of the disease, it is in all probability magnesium deficiency. If this be so, how magnesium supplement by way of 2 or 3 injections could rectify the damage already done to the cerebrospinal system, and

the exact mode of its therapeutic action cannot be explained satisfactorily. (This is subject to correction since the normal range of serum magnesium level in Malnad cattle is not known).

Cerebrospinal nematodiasis

The cause of bovine paralysis and paraplegia, though prevalent as seasonal enzootic in some Malnad tracts of Mysore State for several years, had remained obscure because the investigations undertaken were limited to the search of etiological factors of bacterial, viral or nutritional origin. None of the previous investigators seems to have attempted a detailed histopathological study of the cerebrospinal system. The present study is, therefore, a new approach for the elucidation of the etiology of the disease in this country. The pathological evidence, such as the presence of fully developed larvae of a nematode observed in the softened portion of the spinal cord and transverse sections of immature nematode in the histological sections of the spinal cord with malacic lesions, seem to suggest that enzootic bovine paralysis and paraplegia of some hilly tracts of Mysore State is very probably a form of cerebrospinal nematodiasis. The larvae were sheathed forms but their exact identity could not be determined from the larval and immature forms observed in the cerebrospinal system. The causal nematode is probably a filarid worm.

All the work published so far on cerebrospinal nematodiasis of domestic animals in Japan, Korea and Ceylon indicate that microfilaria of *Setaria digitata* whose natural hosts are cattle, produce cerebrospinal nematodiasis in unnatural hosts like, sheep, goats and horses. Innes [1952] is of the opinion that *Setaria equina* might produce cerebrospinal nematodiasis in cattle and an unnatural host might be necessary for this condition. At the same time Innes [1951] states that "most text books on parasitology admit of great ignorance concerning the life cycle of *Setaria* species and what they do in natural and unnatural hosts". He also mentions that "some statements in Mukteswar reports imply the possibility that the same disease of goats and cattle exists in different parts of India". He also quotes unpublished work of Jensen and Bracken [1950] wherein similar lesions have been described in the sections of brain and spinal cord of cases of a peculiar haemorrhagic encephalomalacia in cattle occurring in the U. S. A.

In the Malnad tracts of Mysore State, where bovine paraplegia is prevalent in the form of enzootic, cattle and buffaloes are predominant and other species of domestic ruminants like sheep and goats are rare. Horses are generally not found in those parts and, therefore, the probability of *Setaria equina* being the causal nematode can easily be ruled out. Of course the hilly and the heavy rainfall area of Mysore State, where bovine paraplegia is prevalent is surrounded by dense forest, abounding also in a variety of wild fauna, including herbivorous animals like deers, antelopes, bisons, etc. as well as a large number of blood sucking insects. Bell [1934] states that species *Setaria labiotopapillosa* occurs not only in the peritoneal cavity of the ox but also in African buffaloes, and various species of deers and antelopes. As cerebrospinal nematodiasis has been observed as a factor associated with the causation of bovine paralysis in Mysore State, the author thinks that the nematode is very probably a filarid worm. If the sheathed larvae encountered in this condition were presumed to be of *Setaria* species, the possible explanation that could



be offered for the incidence of cerebrospinal nematodiasis is that infestation of an unnatural host by a nematode may not always be necessary and the condition may even be produced by it in a normal host.

Though the definite identification of the nematode whose larvae and immature forms were observed in the cerebrospinal system of acute cases of bovine paraplegia and paralysis was not possible, the epidemiological aspects of the disease are highly suggestive of some blood sucking insects playing a role in its transmission. In the endemic area of Mysore State where bovine paraplegia is prevalent, a large number of blood sucking flies are found and cattle are reported to be much harassed by them. As a result of further investigation, some of the blood sucking flies may prove to be the insect vectors in the transmission of the infective larvae.

SUMMARY

(1) Results of investigation of enzootic bovine paraplegia in Mysore State carried out during the period of two years (1952-54) are detailed.

(2) The possibility of this obscure disease being an aberrant form of haemorrhagic septicaemia, contagious bovine pleuropneumonia, acute theileriosis, latent trypanosomiasis or some specific virus disease, etc. is ruled out.

(3) Histopathological studies of the cerebro-spinal systems, particularly the brain and the lumbar portion of the spinal cord from affected animals, have revealed that enzootic bovine paralysis in some Malnad tracts of Mysore State is associated with cerebrospinal nematodiasis.

(4) This seems to be the first record of cerebrospinal nematodiasis among bovines.

ACKNOWLEDGMENT

I am highly grateful to Dr. P. M. Narainswamy Naidu, Director of Animal Husbandry in Mysore, Bangalore, for the encouragement and facilities provided during this investigation and for his guidance in my research work. I am thankful to Shri. M. R. Dhanda, Head of the Division of Pathology and Bacteriology, Indian Veterinary Research Institute, Mukteswar, Kumaon for conducting biological transmission experiments in laboratory animals. I am also thankful to Dr. N. S. Krishna Rao, Parasitologist, Mysore Serum Institute, for his kind co-operation in carrying out surra test, identification of insects, microscopic examination of the nematode and preparation of camera lucida drawings. My thanks are due to Shri H. S. Lakke Gowda, Nutritional Chemist, Mysore Serum Institute, for chemical analysis of blood and to Sarvashri M. Veerabhadrapa, Photomicrographic Technician and Shri M. Saifeulla, Research Scholar, Central College, Bangalore, for their help in preparation of photomicrographs. Lastly I am thankful to Sarvashri V. S. Kuppuswamy Mudaliar, Superintendent, Mysore Serum Institute, K. Srikantiah, Assistant Director, Animal Husbandry, Shimoga, L. R. Phadki and B. S. Kuppuswamy, Veterinary Inspectors of the area for their co-operation in the course of this investigation.

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A PRELIMINARY REPORT ON CYMBIFORMIASIS IN SHEEP AND GOATS OF UTTAR PRADESH HILLS

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(Received for publication on May 10, 1955)

(With Plate V)

CYMBIFORMA indica [Bhalerao, 1942] belongs to the family Notocotylidae of trematodes. Trematodes of Notocotylidae family are characterised by the absence of ventral sucker. The eggs of these trematodes bear long filaments at both ends. These parasites are usually found in the intestines of aquatic birds and mammals. The Notocotylidae are generally regarded to be comparatively harmless. However, Szidat reported that *Catantropis dhner*, 1905, which occurs in the caeca of the fowl, duck, goose and wild aquatic birds attacks the mucosa of caeca and causes erosions.

Cymbiforma indicum was recorded first by Bhalerao in 19'2 in sheep, goats and cattle in India. So far these parasites were considered harmless. Heavy infestations with these trematodes have also escaped the notice of the workers. From the investigations carried out in this State, *Cymbiforma indica* appears to be a serious parasite of sheep and goats. Severe infestations with this parasite developed quite rapidly during the winter season and inflicted heavy loss specially in sheep. Two outbreaks due to heavy infestation with *Cymbiforma indica* have been encountered amongst the sheep of Kumaun hills during the past one year.

Heavy infestation of Rampur Bushair sheep of the Government Sheep Farm, Gwaldam, district Garhwal, with *Cymbiforma indica* was detected for the first time in February, 1954. The disease was limited to Rampur Bushair sheep that had gone to Ali Bugiyal for summer grazing in 1953. Ali Bugiyal meadow is situated about 1200 ft. above sea level in the Kumaun hills and about 15000 sheep and goats are annually sent there from the surrounding villages for summer grazing, i.e. from May to October. Twenty-five Rampur Bushair rams which were transferred in December, 1953 from Gwaldam to the Stud Ram Centre, Badiakote, district Almora, were also affected with Cymbiformiasis. These rams belonged to the same flock of the Gwaldam Farm, which had gone to Bugiyal previous year. Merino and Hissar dale rams which were not sent along with the Rampur Bushair sheep to Ali Bugiyal escaped infestation with *Cymbiforma indica*. It appears that the Rampur Bushair sheep got the infestation with the parasite at Ali Bugiyal.

Frequent intermittent snowfall with unusual heavy winter rains during the months of January and February 1953, were responsible to a great extent for the general deterioration in the condition of sheep at Gwaldam and Badiakote. This lowered the vitality and coupled with heavy infestations with *Cymbiforma indica* caused severe mortality among the sheep. Forty out of 215 sheep and 13 out of 25 rams died at Gwaldam and Badiakote respectively.

Another outbreak of Cymbiformiasis occurred amongst the Rampur Bushair and Kashmiri rams at Kalsi, district Dehra Dun, during December, 1954. Forty stud rams (6 Hissar dale, 23 Rampur Bushair and 11 Kashmiri) were transferred from Chakrata hills (Dehra Dun) to Kalsi in the last week of November 1954. These rams developed the disease after a week of their arrival at Kalsi. The first case was detected on the 1st December, 1954 and 17 rams died within a period of ten days. The change in the environmental conditions together with the strain of long road march seems to be responsible for precipitating the impending attack of the disease.

Symptoms

The following clinical symptoms were manifested by the sheep affected with Cymbiformiasis:

The affected sheep were first noticed dull and lagging behind the flock. Their general condition was poor and debilitated. In a day or two, diarrhoea started with passage of soft faeces which was later replaced by watery diarrhoea with foetid smell, containing flakes of mucus. In the last stages the animal was observed lying in a prostrate condition with the body temperature usually subnormal. Generally, there was no rise in the body temperature at any stage of the disease. Mucopurulent nasal discharge was also observed in a few affected sheep.

The visible mucous membranes were not so pale and anaemic as are seen in immature Amphistomiasis or in chronic cases of Fascioliasis. No oedematous swelling was seen in the affected cases at Kalsi. Four cases of Gwaldam Farm exhibited oedematous swelling in the submandibular region. These cases were found carrying mixed infestations of *Dicrocoelium dendriticum*, *Trichostrongyles* and *Cymbiforma indica* with the latter predominating and largely responsible for the symptoms observed. The duration of illness lasted from 4 to 8 days.

Post-mortem lesions

In all, 16 sheep have been post-mortemed so far. Twelve carcasses were autopsied at Gwaldam, Badiakote and Kalsi. Four sheep in externis were sacrificed to study the disease. The post-mortem lesions observed were as follows:

Heart, lungs, spleen, kidney, rumen, reticulum and omasum did not show any lesion of pathological significance. The thoracic cavity usually contained 8 oz. to 2 lb. of straw coloured serous fluid. The abdominal cavity invariably contained 1 to 3 lb. of serous fluid. The epicardial sac was found to contain 2 to 4 oz. of straw coloured fluid in 5 cases. Gall bladder was always found engorged with thick dark green coloured bile. Liver was slightly enlarged and congested. In six cases liver contained *Dicrocoelium dendriticum* in varying numbers from 44 to 226. Abomasum contained few *Ostertagia circumcincta* in 4 cases.

The pathological lesions and the trematodes *Cymbiforma indica* were detected only in the small intestine. Duodenum generally showed mucopurulent enteritis with marked thickening. The duodenum contained few parasites—*Cymbiforma indica*. The heaviest infestation of the parasites invariably started from the jejunum and continued up to 40 ft. of the ileum, though the parasites were present throughout the small intestine in decreasing numbers. In very heavy infestations the small



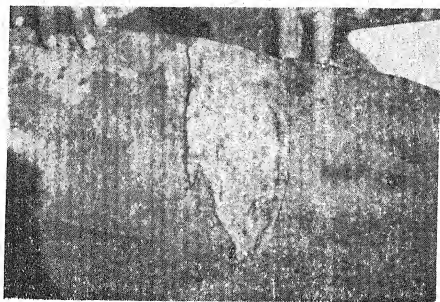


FIG. 1. *Cymbiforma indica* attached to the small intestinal mucous membrane.

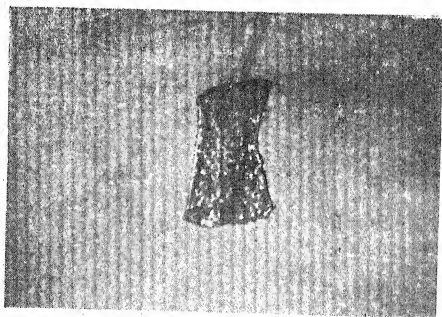


FIG. 2. *Cymbiforma indica* attached to the small intestinal mucous membrane.



FIG. 3. Microphotograph of *Cymbiforma indica*.

intestine on being opened was found full of these parasites Figs. I and II. In about 50 per cent cases haemorrhagic enteritis was present with the blood tinged intestinal contents. In the rest of the cases linear congestion of the intestinal mucous membrane was noticed throughout the small intestine.

These minute trematodes—*Cymbiforma indica*—when fresh and living appeared pinkish in colour with a white speck at one end due to the presence of the anterior sucker. They were easily visible to the trained naked eye on washing the intestinal contents several times. In 12 to 24 hours after the death of the host animals the parasite died out and turned white. In this state they were seen with difficulty and chances are that they may be missed during autopsy.

These parasites were found free in the intestinal contents as well as embedded and adhered to the intestinal membrane. It appears that *Cymbiforma indica* get detached soon after death. These intestinal trematodes after being collected and washed were measured in a measuring cylinder. Their quantity varied from 2 to 8 oz. The parasites were taken in one dram lots and counted. On an average one dram parasites numbered 20,000. The quantity of *Cymbiforma indica* found during autopsies conducted on Kamaun sheep that died of other diseases never exceeded 4 drams.

No *Cymbiforma indica* were detected in the four stomachs and large intestine. Few *Oesophagostomum trigonocephalum* and *Chabertina ovina* were seen in large intestine in some cases.

The identification of the parasites as *Cymbiforma indica* was confirmed by the Indian Veterinary Research Institute, Izatnagar.

Morphology of Cymbiforma indica

These minute trematodes when examined under the microscope were found to be adult parasites full of eggs bearing long filaments at both the poles. The size of the parasite varied from 0.6–2.5 by 0.3–0.84 mm. The adult parasites were pear shaped and concave ventrally. The eggs of the *Cymbiforma indica*, when fresh, were greenish in colour. The one side of the egg was more convex than the other which is almost straight or slightly convex. The filament of one end was longer than the filament at the other end. The eggs measured 20-40 by 11-14 M. Fig. 3.

Degeneration of the parasites

Small pieces of small intestines together with the intestinal contents containing *Cymbiforma indica* were tied at the both ends and were examined after 4, 8, 12 and 24 hours. It was noticed that no degeneration and disintegration of the parasites occurred upto 8 hours. However, there was noticeable reduction in the number of parasites after 12 hours. So degeneration of the parasite appears to take place after the death of the host animal. This degeneration after the death of the animal does not appear so soon as to escape the notice of the worker conducting autopsy. *Cymbiforma indica* were even found in plenty in a Rampur Bushair ram No. 38 which died of Cymbiformiasis and was autopsied after 48 hours of death.

Histopathology

Small pieces of intestines from four sheep which died of Cymbiformiasis were forwarded in 10 per cent formalin to the Indian Veterinary Research Institute, Mukteswar for histopathological examination which showed evidence of superficial necrosis and marked cellular reaction with eosinophilic infiltration. In three cases navicular or boat shaped helminthic ova have been detected in the mucous membrane. Focal leucocytic infiltration into the mucosa were also seen.

Faecal examination

Faecal examination of rectal samples of faeces from affected cases revealed the presence of numerous filamented eggs of greenish colour. The maximum number of eggs of *Cymbiforma indica* seen in a single field under the low power of the microscope was 10.

Examination of faeces from 30 sheep and 30 goats under microscope at Ali Bugiyal (height 12000 ft. above sea level) also showed that about 25 per cent sheep and goats were infested with *Cymbiforma indica*. The infestation of sheep and goats with *Cymbiforma indica* was confirmed by three autopsies conducted at Bugiyal.

Cultural and other examination

Cultures were prepared from heart blood, lungs, liver and spleen at the time of post-mortems. Examination of these cultures did not show any organism of pathological significance.

Transmissions were tried in two healthy young sheep by intravenous injections of 10 c.c. of blood taken from affected sheep. The inoculated sheep were kept under observation for 10 days. These experimental sheep did not develop any signs of illness.

Pathogenicity

Manifestation of clinical symptoms accompanied with pathological lesions and mortality in the affected animals is indicative that these intestinal trematodes—*Cymbiforma indica*—cause heavy mortality in sheep when they are present in large number. It appears that in conjunction with the predisposing causes, i.e. poor nutrition, adverse climatic condition, strain caused by long road marches, these parasites assume a more pathogenic significance.

Seasonal incidence. Heavy infestations with *Cymbiforma indica* occurred from November to February.

Localities affected. So far infestation of sheep and goats with *Cymbiforma indica* has been detected in Garhwal district and Chakrata hills of Dehra Dun district of U. P. hills. Enquiries made show that cymbiformiasis is present throughout the Kamuan hills of Uttar Pradesh. Fifteen out of 176 newly purchased Rampur Bushair sheep were detected carrying filamented eggs of *cymbiforma indica* on the microscopic examination of the rectal samples of faeces just after two weeks of their arrival from Himachal Pradesh in the month of December, 1954. Last year four Rampur Bushair sheep out of the purchased lot of 150 from Himachal Pradesh died on their arrival at Gwaldam. On autopsy heavy infestations with *cymbiforma indica* were detected.

Treatment. Treatment was undertaken with carbon-tetrachloride and hexachloroethane. All the sheep of the Government Sheep Farm, Gwaldam were divided into two equal groups. One group was administered carbon tetrachloride in the doses of 1 to 2 c.c. with 4-8 c.c. of liquid paraffin. Hexachloroethane was given to the other group in the doses of 2 to 4 drams. Administration of both the drugs was immediately preceded by dosing the sheep with 10 c.c. of 5 per cent copper sulphate solution to close the oesophageal groove and to allow the passage of the drug direct into abomasum. Treatment was repeated after 21 days. Efficacy of the anthelmintics was checked by faecal examination and post-mortem examination of animals that died after treatment. The second dose of anthelmintics stopped the mortality and saved 60 per cent of the clinically affected sheep. Faeces were found negative for the filamented eggs. No fresh clinical cases occurred even after the first dosing.

In five cases tetra-chloroethylene was tried without any appreciable benefit.

All the remaining 25 stud rams at Kaisi out of which five were showing clinical symptoms of cymbiformiasis, were treated with carbontetrachloride in the doses of 2 c.c. with 8 c.c. of liquid paraffin. Administration of carbontetrachloride was immediately preceded by dosing with 10 c.c. of 5 per cent solution of copper sulphate. Two out of the five clinically affected rams died and the rest three recovered. The treatment was repeated after three weeks. No case of cymbiformiasis developed after that.

The above line of treatment undoubtedly controlled the outbreaks of Cymbiformiasis. Both carbon tetrachloride and hexachloroethane proved equally satisfactory in combating cymbiformiasis.

SUMMARY

1. Two outbreaks of Cymbiformiasis amongst the sheep of Uttar Pradesh hills are described.

2. Heavy infestation of intestines of sheep with *Cymbiforma indica*, produce a serious diseased condition accompanied with heavy mortality. These trematodes were considered so far harmless.

3. The duration of illness lasted 4 to 8 days with the clinical symptoms of anaemia, debility and diarrhoea. In some cases the oedematous swelling in the lower jaw was noticed.

4. Mucopurulent enteritis with minute trematodes—*Cymbiforma indica*—millions in number were found in the first 40 ft. of the small intestine. These parasites, when fresh and living, appeared pinkish in colour with a white speck at one end. The parasites were found free in the intestinal contents as well as embedded and adhered to the intestinal membrane. No other endoparasites were present constantly in any significant numbers.

5. Histopathological examination of intestine of the animal that died of cymbiformiasis showed superficial necrosis and marked cellular reaction with eosinophilic infiltration. Navicular or boat shaped helminthic ova were detected in the mucous membrane.



6. Hexachloroethane and carbon-tetrachloride were found equally efficacious in combating cymbiformiasis. Tetra-chloroethylene was tried without any appreciable result.

7. This preliminary study indicates that *Cymbiforma indica* assumes pathogenicity when present in large number and causes heavy mortality amongst sheep of Uttar Pradesh hills.

ACKNOWLEDGMENT

I am exceedingly grateful to Dr R. L. Kaura, Director of Animal Husbandry, U. P. for his guidance and the facilities given for the above work and also for his valuable suggestions in writing this note. Thanks are due to Shri G. P. Singh, Veterinary Assistant Surgeon, attached to the Assistant Disease Investigation Officer (sheep and goats) for assistance rendered in the above work. I am also thankful to the Indian Council of Agricultural Research, New Delhi, for the grant of the scheme under which this work was carried out.

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STUDIES ON THE CERCARIAL FAUNA IN MADRAS—IV

THE AMPHISTOME AND GYMNOCEPHALOUS GROUPS OF CERCARIAE*

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(Received for publication on August 17, 1955)

AMONG the many forms of cercariae met with in an extensive study of the trematode infection in fresh-water snails in the city of Madras made during 1947-49, four were of the amphistome group and three of the gymnocephalous group. They are enumerated below under their respective groups:

(a) Amphistome group

- (i) *Cercariae indicae* xxvi Sewell, 1922
- (ii) *C. indicae* xxix Sewell, 1922
- (iii) *Cercaria kylasami* Rao, 1932
- (iv) *C. gastrodisci secundi* Peter and Mudaliar, 1948

(b) Gymnocephalous group

- (i) *Cercariae indicae* iii Sewell, 1922
- (ii) *C. indicae* vii Sewell, 1922
- (iii) *C. indicae* viii Sewell, 1922

Excepting *Cercariae indicae* xxix which was discharged by *Limnaea luteola* f. *succinea* (Deshayes), the other three amphistomes were found developing in *Indoplanorbis exustus* (Deshayes) and all the gymnocephalous species in *Melanoides tuberculatus* (Muller).

THE AMPHISTOME CERCARIAE

These are amongst the largest known cercariae having a powerful muscular tail and a prominent body with two conspicuous eye-spots, a body-wall carrying cystogenous cells and in many cases dark pigment granules, a well-defined posteriorly-situated acetabulum, a triclad digestive tract and two main excretory trunks packed with globular refractile granules. They develop in redial parthenitae, are born immature and complete their development in the tissue of the host before they are discharged into the surrounding medium of water. They encyst readily in the open.

The accepted classification of the amphistome cercariae at present is that of Sewell [1922], who created two sub-groups, viz. the 'Pigmentata' and the 'Diplocotylea', the main distinguishing feature of the two being the presence of an excretory cross-connection in the former and the absence of the same in the latter. Based

*Part of a thesis approved by the University of Madras for the Degree of Master of Science

on this scheme, *Cercariae indicæ xxvi* and *C. indicæ xxix* come under the 'Pigmentata' and *Cercaria kylasami* and *C. gastrodisci secundi* under the 'Diplocotylen'. Excepting the latter species, the other three as well as *Cercaria fraseri* Buckley, [1939], which was not encountered during the present studies, were known to occur previously in the city of Madras [Rao, 1932 a and b; Anantaraman and Balasubramaniam, 1949].

Cercariae indicæ XXVI Sewell, 1922

Amongst the known amphistome cercariae in India, *Cercariae indicæ xxvi* appears to be the one enjoying wide distribution throughout the country. It was first described by Sewell [1922] who recorded it from Calcutta and Malabar. Subsequently, Rao [1932b] and Anantaraman and Balasubramaniam [1949] obtained it from Madras City, while Bhalerao [1943], from Hyderabad. In every case, *Indoplanorbis exustus* was found to act as the molluscan host. Out of a total of 3,863 specimens of *I. exustus* examined during the present investigation, 3.5 per cent of them discharged this larva, which constituted about one-half of the amphistome infection and nearly one-third of the total cercarial infection in the snail species in the city of Madras.

Rao and Ayyar [1932] believed that the adult fluke of this cercaria, which they had raised by experimental means, was referable to *Paramphistomum cervi* (Zeder); whereas, Pande [1935] and Mudaliar [1945] thought that the larva would develop into *Cotylophoron cotylophorum* (Fischdr) and it was experimentally proved to be the case by Bhalerao [1945]. On the contrary, Bennett [1936], Srivastava [1938] and Sinha [1950] who studied the life-history of *C. cotylophorum* in detail described its cercaria as distinct from *Cercariae indicæ xxvi*. Actual relationship, if any, of this larva to *C. cotylophorum* thus still remains to be elucidated.

Cercariae indicæ XXIX Sewell, 1922

This amphistome larva is found to develop in more than one species of snail host. Sewell [1922] first obtained it from *Limnaea acuminata* and *Agraulus euphraticus* in Calcutta and from *L. succinea* in Malabar; whereas, Rao [1932b] and Vaidyanathan [1941] in Madras, and Bhalerao [1943] in Hyderabad recorded it from *Limnaea huteola*. During the present studies, only *L. succinea* was found harbouring this cercaria in Madras City, the percentage of infected snails being 5.4 in 1,545 individuals examined.

C. indicæ xxix has been shown to give rise to *Fischoederius elongatus* (Poirier) by Rao and Ayyar [1932] and Vaidyanathan [1941].

Cercaria kylasami Rao, 1932

Rao [1932a] first obtained this cercaria from *Indoplanorbis exustus* in Madras City. In comparison to the other amphistome cercariae in *I. exustus*, the frequency of occurrence of this larva has been found by the author to be the lowest, only 0.3 per cent of the snails carrying the infection.

Cercaria Gastrodisci secundi Peter and Mudaliar, 1948

This cercaria which was newly encountered in *Indoplanorbis exustus* during the present studies and proved to be the larva of *Gastrodiscus secundus* Looss by transmission experiments [Peter and Mudaliar, 1948], occurs very commonly in Madras City, making its appearance in all seasons of the year. The rate of infection with this amphistome in *I. exustus* is found to be 3-7 per cent which is the highest of all the different kinds of amphistome infection recorded in the snail species. Curiously enough, nowhere else the existence of this cercaria has been reported, although its adult, *Gastrodiscus secundus*, is frequently met with everywhere in this country as a common parasite in equines and rarely in elephants.

THE GYMNOCEPHALOUS CERCARIAE

Dawes [1946] recognized the group of 'Gymnocephalous cercariae' as consisting of all the four sub-groups (Parapleurolophocerca, Isoporti, Agilis and Reflexae) of the 'Distome Cercariae' and one (Pleurolophocerca) of the 'Monostome Cercariae' created by Sewell [1922]. The three gymnocephalous cercariae encountered during the present investigations in *Melanoides tuberculatus* belong to the 'Pleurolophocerca'. There is no previous record of their occurrence in Madras City. Apart from the absence of a ventral sucker in the members of this sub-group, they are characterised also by the presence of a pair of pigmented eye-spots, an armed oral sucker designed for penetration, a rudimentary alimentary canal, a pair of conspicuous salivary glands, a thick-walled reniform excretory bladder and a powerful muscular tail provided with well-developed cuticular fin-folds.

Cercariae indicae III Sewell, 1922

This was originally recorded in India as a 'Small monostome' from *Melanoides tuberculatus* and *M. lineatus* by Kemp and Gravely [1919]. Subsequently, it was fully described under the name *Cercariae indicae iii* by Sewell [1922] who reported its occurrence in *M. tuberculatus* at Calcutta, Bombay and Malabar, in *M. scabra* var. *elegans* at Malabar and *M. lineatus* at Calcutta. Only one specimen of *M. tuberculatus* was found to harbour this larva during the present studies in Madras.

Cercariae indicae VII Sewell, 1922

This larva, which is very similar to *Cercaria pleurolophocerca* Sons., was first obtained from *Melanoides lineatus*, *Acrostoma variabile* and *Bithynia* sp. by Kemp and Gravely [1919] who considered it under the title 'Large monostome'. Sewell [1922] came across this species only in *M. tuberculatus* collected from Calcutta and Bombay and redescribed it as *Cercariae indicae vii*. As observed during the present studies, the occurrence of this species of cercaria in Madras City is also rare since only 3 out of 282 *M. tuberculatus* examined discharged it. This pleurolophocercous cercaria has also been reported from Andhra [Ramannujachari and Alwar, 1954].

Cercariae indicae VIII Sewell, 1922

This form was first found by Sewell [1922] in *Melanoides tuberculatus* at Calcutta, Bombay and Malabar, in *Digoniostoma cerameopoma* at Calcutta and in *Acrostoma variabile* var. *spiniferum* from Assam. It also occurs in Hyderabad [Bhalerao, 1943]

and in Andhra [Ramanujachari and Alwar, 1954]. In Madras City, eight out of 282 specimens of *M. tuberculatus* were found infected with this trematode larva.

SUMMARY

Four species of amphistome cercariae (two belonging to the 'Pigmentata' type and two to the 'Diplocotylea') and three of the gymnocephalous cercariae (belonging to the 'Pleurolophocerca') were encountered in the city of Madras, of which the occurrence of *Cercaria gastrodisci secundi* Peter and Mudaliar in *Indoplanorbis exustus* and of *Cercariae indicae* iii, vii and viii Sewell in *Melanoides tuberculatus* has not been previously reported from there.

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INHIBITORY EFFECT OF KAMALA (*MALLOTUS PHILIPPINENSIS*) ON SUCCINIC DEHYDROGENASE OF TAPE WORM (*MONIEZIA EXPANSA*)

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(Received for publication on April 29, 1955)

FOR nearly a century, *kamala*, consisting of hairs and glands of the fruits of *Mallotus philippinensis* Muel Arg. has been regarded as a good anthelmintic against tape worms and has been included as such in both the *British Pharmaceutical Codex* [1934] and the *British Veterinary Codex* [1953]. The drug is obtained by rubbing the small three-celled fruits and sifting the resulting powder. The precise way by which this drug exerts its anthelmintic action is, however, not known. An attempt has been made to find out whether the activity of *kamala*, could be correlated with any of its effects on the various enzyme systems [Buiding, 1949] present in the tape worm, and thus interfering with its metabolism. This article reports the results of study of the action of the drug on succinic dehydrogenase of *Moniezia expansa*.

MATERIAL AND METHODS

Enzyme preparation. The preparation was made from the whole worm (*Moniezia expansa*) obtained fresh from slaughter house in an iced container. The worms were crushed and extracted twice with phosphate buffer (pH 7.0) by adding 10 c.c. per 5 gm. of the worm tissue. The extract was then centrifuged at 3,000 R.P.M. and was employed as such. For each experiment a fresh extract was made in the above manner, except for the experiments carried out to study the effects of change in pH, where the worms were extracted in distilled water instead of phosphate buffer and the quantity of water used for this purpose was half that of the buffer used for the other experiments.

Kamala solution. The solution was obtained by dissolving a known quantity of the drug in minimum quantity of caustic soda solution (10 per cent) neutralising this with HCl (10 per cent) and finally diluting the resultant solution with distilled water to the desired concentration.

Sodium succinate solution. An M/3 stock solution of sodium succinate was first prepared and any desired concentration was subsequently obtained by suitable dilution with water.

Methylene Blue. (1 : 5000) 0.2 gm. of the dye was dissolved in a litre of distilled water.

Phosphate buffer. The two stock solutions of Na_2HPO_4 and KH_2PO_4 (M/15) were prepared according to Sorensen.

Determination of succinic dehydrogenase activity. The enzyme activity was determined by employing Thunberg's technique, using methylene blue as an indicator. The time taken for 50 per cent reduction of the dye was determined by comparison with the standard. Inhibition was studied at 37°C. in all experiments.

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The concentration of the different constituents taken are mentioned under each experiment described below.

EXPERIMENTAL PROCEDURE AND RESULTS

Experiment I. The degree of enzyme inhibition was studied by employing different concentrations of *kamala* on a known amount of the enzyme. 1 cc. of *kamala* solution (of different concentrations) and 0.3 cc. of the enzymic extract were taken in the hollow stopper and 1 cc. of methylene blue and 1 cc. of the substrate in the tube. The Thunberg tubes were then quickly evacuated, the contents mixed and the tubes kept at 37°C. till 50 per cent reduction of methylene blue was obtained. The time was recorded and the corresponding activity calculated. Each figure in the Table corresponds to mean of three observations obtained in this manner. The results are summarised in Table I.

TABLE I
Variation of inhibitory effect with change in concentration of kamala

Number	Concentration of <i>Kamala</i>	Percentage activity ($A = 1/T \times 100$)	Percentage inhibition
Control	0	11.1	0
1	1:5000	8.3	25
2	1:4000	4.0	64
3	1:3000	3.3	70
4	1:2000	2.2	80
5	1:1000	0.78	93

It will be seen from Table I that the percentage inhibition of the enzyme increases progressively with increase in drug concentration.

Experiment II. The substrate (1 cc.), methylene blue (1 cc.) and the phosphate buffer (1 cc.) of required pH were taken in the tube, and 0.3 cc. of the enzymic extract and 1 cc. of the inhibitor in the hollow stopper. The rest of the procedure was identical with that followed in the Experiment I. Suitable controls were run at different pH levels by replacing inhibitor with water, and the percentage increase of time for 50 per cent inhibition was calculated at these pH levels.

TABLE II
The effect of change of pH on the inhibition produced by kamala

Number.	pH	Time of reduction (in minutes)		Percentage increases of time for 50 per cent inhibition
		With <i>Kamala</i>	With water (control)	
1	6.0	75	36	108
2	7.0	45	18	150
3	7.4	33	13	154
4	8.4	27	10	170

It is evident from Table II that with the shift of pH towards the alkaline region the time for inhibition correspondingly increases.

Experiment III. The same procedure (Experiment I) was employed except that substrate concentrations were in this series varied. The concentration of *kamala* used in this experiment was 1/1000. The results are given in Table III.

TABLE III

Variation of Inhibitory effect of kamala with change in concentration of the substrate

Number	Concentration of the substrate	Percentage Activity ($A = 1/T \times 100$)	Percentage inhibition
1	M/10	0.74	85
2	M/6	1.33	72
3	M/4	2.22	53
4	M/3	4.7	30

It is observed, that with a constant concentration of *kamala* the percentage activity of the enzyme increased with increase in substrate concentration, and the percentage inhibition of the enzyme was correspondingly reduced.

Experiment IV. The enzyme and the inhibitor (*kamala* 1: 2000) were kept together for different intervals of time to allow for the absorption of the inhibitor on the enzyme surface and then activity of the enzyme was determined by combining it with the substrate, etc. in the manner outlined before. The results are presented in Table IV.

TABLE IV

The effect of change in time of contact on the inhibition produced by kamala

Number	Time of contact (in hours)	Percentage Activity ($A = 1/T \times 100$)	Percentage inhibition
Control	0	11.1	0
1	0	3.3	73.0
2	2	2.5	74.0
3	4	2.0	81.9
4	6	1.5	86.4

It is clear from Table IV that with the increase in time of contact, the percentage activity of the enzyme lessens and the percentage inhibition increases accordingly.

DISCUSSION

The result of the present study show that the drug *kamala*, has a pronounced inhibitory action on the succinic dehydrogenase activity of *Moniezia expansa*. In view of the importance of succinic acid as one of the stages in the conversion of pyruvic acid to carbon dioxide and water, and the possibility of pyruvic acid being the intermediate not only in the carbo-hydrate metabolism (Kreb's), but also in the fat and protein metabolisms; it is quite possible that inhibition of this enzyme by the drug may be one of the factors responsible for its anthelmintic properties.

It was observed that increase in concentration of the drug brings about an increase in inhibition of the enzyme. Furthermore, it was found that the inhibition of the enzyme decreases with the increase in the concentration of the substrate. This indicates that the drug and the substrate may have the same point of attack on the enzyme. As the concentration of the substrate is reduced, the points of attachment for the drug on the enzyme surface are increased and hence there is an increase in inhibition. These findings suggest that the inhibition produced by *kamala* is of the competitive type.

SUMMARY

1. *Kamala* inhibits the succinic dehydrogenase activity of the worm.
2. The degree of inhibition of the enzyme increases progressively with the increase in concentration of *kamala*.
3. The inhibition increases progressively in the alkaline region.
4. The percentage inhibition produced by *kamala* decreases with the increase in concentration of the substrate.
5. The inhibition increases with the increase in time of contact of the drug and the enzyme.

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CONTROL OF FERTILITY IN FARM ANIMALS

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(Received for publication on July 23, 1954)

LITTLE is known about the phenotypic and genetic correlations between animal fertility and high production. In the Swedish highland cattle [Lagerlof, 1950; Lagerlof and Boyd, 1952] hypoplasia is associated with more butter-fat, and cystic ovaries with greater quantity of milk. Thus selective breeding for high production tends to spread sterility. There is always an interaction between climate, husbandry methods and the genetic makeup of the animal.

The main components of climate involved in the expression of fertility are the daylight environment and temperature. Their effects vary markedly with the species and locality. Bovine fertility is associated with the ultra-violet components of sunshine [Abrams, 1952]. It seems that short hours are detrimental in high latitudes whereas high temperatures are detrimental at low latitudes. In sheep, however, the short-days environment coincides with high fertility, especially at high latitudes [Hafez, 1952a]. Meanwhile high atmospheric temperature is inimical to satisfactory gestation and causes a decrease in birth weight in sheep [Yeates, 1953].

The age and size at which the animals are bred are important factors with regard to the economics of milk production. In cattle, the highest milk yields and the greatest number of calves are produced when the first service is 16 to 18 months, the growth and development of subsequent production of the resulting calves being normal [Usakov, 1953]. There is always a positive correlation between milk production of the first half of lactation and the service period [Olds and Seath, 1953]. However, the fertility level is affected by the service period [Olds *et al.*, 1949; Van Denark and Salisbury, 1950], as well as the time of service during the heat period [Trimberger and Davis, 1943; Trimberger, 1948], the season of mating [Badreldin, 1952; Sidky, 1953] and the method of breeding. In sheep, artificial insemination with mixed semen (from two rams) increases lambing percentage, birth weight and subsequent growth rate [Causovskii, 1952].

Inbreeding generally results in reduced fertility [Woodward and Graves, 1946] the exact degree of which depends on the male because bulls differ considerably in their fertility [Milk Marketing Board, 1950]. The bulls also differ in respect of their daughters' fertility. There is little evidence to show that herd differences in the fertility level are genetic [Trimberger and Davies, 1955; Olds and Seath, 1950]. In cattle, the heritability and repeatability of the cycle length is very low [Asdell, 1952]. Thus selection for fertility is not very effective.

In the improvement of farm animals, special stress is laid on the development of certain characters like high milk production, high growth rate as well as high

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fertility. The physiological means by which the activity of one particular part of the body is stimulated is largely through the hormones [Hammond, 1950].

The present study is an attempt to recommend practical husbandry methods to control fertility in ruminating farm animals.

MATERIAL AND METHODS

The experimental material of this investigation comprised 33 domestic buffalo-cows *Bos (Bubalus) bubalis*, 22 Egyptian cows, and 99 fat-tailed ewes (Ossimi and Rahmani breeds) of different ages. Fertile males for each class of animals were available. The animals were kept at the Animal Breeding Research Farm, Giza, and were previously inbred for over 12 years. Cows and buffalo-cows were fastened in double-row stables by means of chains and neck-halters while the ewes were running in open paddocks. All the males were oched on the brisket with coloured grease and were joined with the females daily. Records were kept for the incidence of oestrus, mating and conception for over two years. The animals were fed on green clover *Trifolium alexandrinum* during the winter and with a mixture of concentrates (barley, horse beans, rice polish and cottonseed cake) and green maize during the summer months. In buffalo-cows and cows, rectal palpation was carried out at intervals in non-pregnant and in pregnant animals 60, 90 and 120 days after service. Parturitions took place under close observation and the placental membranes (after-birth) were carefully examined for detection of any foetal mortality. In addition, the previous reproductive records of all the animals were inspected.

Non-pregnant genitalia from 30 cows and 45 buffalo cows were brought from Cairo slaughter house during the months of September and October. The ovaries were examined macroscopically to determine the ovulation rate of the three species of farm animals. Pregnant genitalia from 70 buffalo-cows and 40 cows were also examined to detect the percentage of healthy pregnancies.

RESULTS

In buffalo-cows, the percentage of conception, which required one, two and three or more services were 56, 22.8 and 14 respectively. The average number of services per conception was 1.46 while the average breeding efficiency as a whole was 93 per cent. The average cycle length was 21.14 days. One silent heat occurred in 30 per cent of the cases, with an average cycle length of 44 days. Two successive silent heats occurred in 11 per cent of the cases with an average cycle length of 69 days. The interval to *post partum* oestrus ranged from 10 to 76 days with an average of 38 days. (Table I).

In Egyptian cows the number of services required for conception ranged from 1 to 5 with an average of 2.0. The percentage of conceptions which required one, two, three or more services were 54, 20.9, and 17 respectively. The interval to *post partum* oestrus ranged from 12 to 60 days with an average of 38 days. Post mortem examination of the cows' ovaries after calving showed that the first *post partum* cycles were ovulatory.

TABLE I.

Fertility measures in Egyptian livestock (adults)

Observation	Buffalo-cows (per cent)	Cows (per cent)	Ewe	
			Rahmani (per cent)	Ossimi (per cent)
Conception after :				
1 service	56	54	50	0
2 services	22	20	10	42
3 services	8	9	10	16
more than 3 services	14	17	30	42
Average services per conception	1.46	2.0	1.8	2.3
Range of cycle length (days)	8.25—24.50			
Average cycle length (days)	21.14 \pm 0.3	21.33 \pm 0.3	18.1 \pm 0.4	17.7 \pm 0.3
1 silent heat	30 per cent	17 per cent	11 per cent	7 per cent
2 silent heats	11 per cent	12 per cent	..	..
Interval to post partum oestrus(days)				
Range	10—76	12—60	17—62	28—63
Mean	38 \pm 1.2	38 \pm 1.1	40 \pm 1.0	41 \pm 1.4

Fat-tailed ewe lambs experienced their first oestrus from October to January. In the Rahmani ewe lambs, conception took place at the first oestrus in all cases. Only 33 per cent of the Ossimi ewe lambs conceived after one service, whilst another 33 per cent required two services and 33 per cent of the individuals required from three to six services per conception. In Ossimi and Rahmani ewes, oestrus and conception occurred some 40 days after lambing. In the Rahmani adults, the percentages of conceptions which required one, two three or more services were 50, 10, 10 and 30 respectively. In the Ossimi adults, the percentages of conceptions which required two, three or more services were 42, 16 and 42 respectively. The length of lactation anoestrus was inversely related to the live weight of the mother. When the rams were joined with the non-pregnant dry adult ewes in December, the latter began to show oestrus at intervals varying from 1 to 44 days with an average of 15 or 18 days (an average for one cycle length). In the Rahmani dry ewes, conception took place after one, two, three and four services in 50 per cent, 10 per cent, 10 per cent and 10 per cent of the cases respectively. In 20 per cent of the cases conception did not occur. In the Ossimi dry ewes, conception required two and three services in 42 per cent and 16 per cent of the individuals respectively. In 42 per cent of the cases conception did not occur.

Post-mortem examination of the ovaries showed that twin ovulations never occurred in buffalo-cows while there were rare cases (0.8 per cent) in the cows. The

examination of pregnant genitalia showed the incidence of embryonic mortality in 9 per cent of the buffalo-cows and 8 per cent of the cows. The dissection of the after birth showed no signs of embryonic remains in the three classes of animals.

DISCUSSION

In buffalo-cows the breeding efficiency was considerably higher than that reported by Hafez [1952b] from the breeding records under free mating conditions. The interval to *post partum* conception in the present study was shorter than that reported by Hafez [1954]. The previous records for the breeding efficiency was 85-80 per cent and the interval to *post partum* conception 43 days on an average. This shows that some of the oestrus cycles were either of short duration or of weak symptoms. Such cycles can be detected by close observation and by continuous association with the buffalo-bull. This point is of major significance in practical buffalo breeding.

The proximity of the male has an effect on the degree of receptivity of the female and probably on the duration of oestrus [Hafez, 1951]. Cows which are classified as shy breeders (showing weak signs of oestrus) must be joined continuously with the bulls when mating is desired. In general expectancy lists of oestrus must be kept for all the breeding females (calculating the expected cycle by adding some 21 days to the previous oestrus) so as to raise the reproductive efficiency. Since the interval from calving to conception is unduly prolonged, it is advisable to mate the buffalo-cow some 30 to 40 days after calving instead of the usual practice of 60 days. The probable decrease in the milk yield due to subsequent pregnancy would be less expensive than cutting down the reproductive potentiality of the animal which is as good as risking a whole lactation.

Since the genotype environment may be important in fertility [Hignett, 1950] breeds or types adapted to particular environments are required to obtain maximum fertility. The best genetic method for achieving fertility is not by selection but by crossing. A certain amount of risk is attached to the use of first calves (in sequence of calving) for breeding unless adequate reproductive records of ancestors and sisters of the dam are available, as data on the dams' own performance at that time are insufficient.

The common measure of fertility usually used is the conception rate in various forms. This is unsatisfactory since it does not take into account those animals which fail to show reproductive regularity. Calving intervals are also used as a measure of fertility. They do not include animals which have calved and may be biased by deliberate extension of their intervals to obtain maximum production from persistent milkers. Meanwhile little is known about the extent to which dams differ in their ability to produce offsprings of high or low conception rate. On the other hand, there is little information on the extent to which the differences between bulls are genetic and are capable of being transmitted from bull to bull.

The Egyptian fat-tailed ewe lambs showed their first oestrus during the shortest days of the year (December). This is in agreement with a previous report by Hafez (1952a). Conception in the Rahmani ewe lambs took place after an average of 1.1 services. This shows that the first oestrus was accompanied by ovulation. It is suggested here that the first observed oestrus was preceded by one or more silent heats (ovulations without oestrus) as the ewe lambs show in the field some sexual desire

about 16 days before the first heat. Lactation in the ewe did not inhibit the expression of oestrus. Breed differences as well as individual differences were recorded for the age at first oestrus, and the number of services per conception. This is either due to the different inherited levels of output of the adenohypophysis among the breeds or to the different reactions of the individuals to the environment. There is much evidence of a general nature that the varying degrees of activity of the gland are inherited. Genetic analysis of this character is rather difficult due to the interaction of the different hormones and the genetic factors.

SUMMARY

In the expression of fertility there is an interaction between the components of climate (mainly daylight and temperature), husbandry methods and the genetic make-up of the animal. Thirty-three buffalo-cows, 22 Egyptian cows and 99 fat-tailed sheep were tested with ochred teasers daily. Fertile services were allowed and the conception and parturitions recorded. Rectal palpation was carried out in big animals while all the after-births were dissected. Non-pregnant and pregnant genitalia of two classes of animals were examined to investigate ovulation rates and the health of pregnancy.

In the buffalo-cow, the percentage of conceptions requiring one, two and three services were 56, 22 and 8 respectively. The average interval to *post partum* oestrus was 35 days in the buffalo-cow, 38 days in the cow and 40 days in fat-tailed ewes. Twin ovulations were never observed in the buffalo-cows and were rare in the cows. Embryonic mortality occurred in 9 per cent of the buffalo-cows and 8 per cent of the cows.

The breeding efficiency of the female of farm animals was raised by continuous association with ochred fertile males. Reproduction sheets are also recommended. The incidence of first oestrus, *post partum* oestrus, silent heat and reproductive disorders (mainly foetal mortality) must be considered. Rectal palpation of pregnant animals should be carried out at intervals to confirm healthy pregnancies. The after birth of breeding animals as well as the genitalia of culled animals should be examined.

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OXYHAEMOGLOBIN CRYSTALS OF EGYPTIAN BUFFALO AND CATTLE

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(Received for publication on June 8, 1955)

(With Plate VI)

IT has been reported in an earlier paper [Hafez and Anwar, 1954] that the comparative studies of normal haematological values are of great significance in investigating the origin and evolutionary trends of species and breeds. Genera and species differences in the crystallography of haemoglobin have been extensively studied by Richard and Brown [1909] from the view points of the axial ratio, prism angle, angle B, extinction angle, optical character and the crystallographic system. In this respect, a study of the oxyhaemoglobin crystals of the Egyptian buffalo *Bos (Bubalus) bubalis* L., and cattle has been carried out.

Oxyhaemoglobin crystals were prepared from the blood of adult Egyptian buffaloes and cattle. Fresh blood samples were centrifuged and the plasma-free corpuscles laked with ether. The solutions were saturated with ammonium oxalate and recentrifuged. A drop of the laked blood was allowed to evaporate on a slide and examined microscopically as well as by a "Reichert Wien" microprojector.

Oxyhaemoglobin crystals of the buffalo were orthorhombic with 90° angle B. They were relatively very long, lath-shaped and (1 : 9.46) elongated on the vertical axis. The formed crystals ranged from 50μ to 120μ in length. In the cattle, the crystals were prismatic (1 : 6.72), orthorhombic with angle 90° B. The formed crystals ranged from 50μ to 170μ in length (Plate VI). The rate of formation of crystals was found to depend on the concentration of haemoglobin and of other ions in the solution, surface tension as well as temperature.

The oxyhaemoglobin crystals of the Egyptian buffalo *Bos (Bubalus) bubalis*, L. are similar to those of '*Bos bison*', reported by Reichart and Brown [1909]. It does not seem that domestication has any effect on the crystallography of oxyhaemoglobin and it would appear that the picture of oxyhaemoglobin crystals is similar in both domesticable buffalo and non-domesticable buffalo '*Bos*, caffer' of South Africa. This is an experimental evidence that the haemoglobin molecule in both the animals, (buffalo and bison) is identical. The oxyhaemoglobin crystals of the Egyptian cattle are similar to those of *Bos, taurus* [Reichert and Brown, 1909] being prismatic, orthorhombic with 90° angle B. (Table I).

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TABLE I

Oxyhaemoglobin crystals in Egyptian buffalo and cattle

Characteristics of crystals	Buffalo	Cattle
Shape	Orthorhombic (1 : 9.46)	Orthorhombic (1 : 6.72)
Angle B	90°	90°
Length (Range)	50-120 μ	50-170 μ

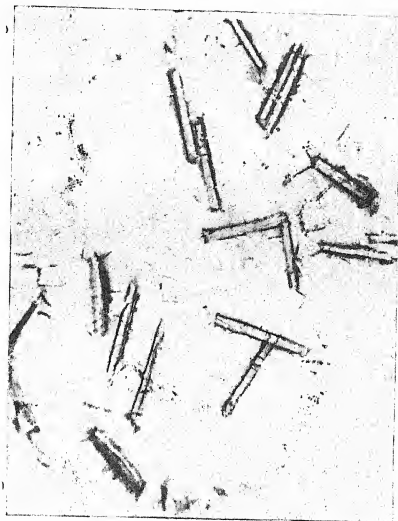
Further comparative studies are required to find out the crystallographic characters of oxyhaemoglobin in the Indian buffalo, which is considered to be the origin of improved breeds of buffaloes in many parts of the continent. The different pictures of oxyhaemoglobin crystals in the cattle and buffalo denote different positions along the evolutionary scale, this may explain the sterile matings between the two animals [Hafez, 1955]. Whether the matings between the buffalo and American bison are fertile or sterile is still an open question.

ACKNOWLEDGMENT

This work has been carried out in the Animal Production Research Farm, Faculty of Agriculture, Giza, Egypt. Thanks are due to Prof. A. I. Badreldin, Faculty of Agriculture and to Dr M. H. Maghraby of the Ministry of Agriculture for providing facilities and help.

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Oxyhaemoglobin crystals (X 200)
Top : Buffalo, bottom : Cow.



ABSTRACTS

Johne's disease in sheep. STAMP, J. T. and WATT, J. A. (1954), *J. Comp. Path & Therap* 64 (1), 26-40.

ON the basis of histological changes the authors divided Johne's disease in sheep, as it occurs in Scotland, into four groups.

In group I the mucous membrane of jejunum and ileum was thickened, granular and yellowish in colour, and the associated lymph nodes were oedematous. Islands of epithelioid cell infiltration were found in the mucosa and submucosa of the intestines as well as in the subcapsular sinus of the lymph nodes. Pigmented variety of *M. johnei* was isolated and a large number of the organisms could be detected in the smears and sections of the intestines and lymph nodes.

The intestinal mucous membrane in group II, showed no yellow discolouration and its thickness and granulation was frequently slight. The mucous membrane, the submucosa and the associated mesenteric lymph nodes showed varying degrees of epithelioid cell infiltration. Number of *M. johnei* in the smears and sections of the intestine was not as great as in group I.

In group III, in the thickened lamina propria of the intestine was detected focal infiltration with epithelioid cells, many of which were multinucleated. Giant cells of Langhans or foreign-body types were seen distributed individually or in groups. The lymphoid follicles in the submucosa and the cortex of the enlarged and oedematous lymph nodes showed epithelioid cell infiltration with evidence of necrotic changes. In majority of the cases, smears and sections of the intestine and the associated lymph nodes failed to show *M. johnei*; on cultural examination, however, 14 out of 21 cases proved positive for non-chromogenic type of the organism.

In group IV, hard and calcified nodules were detected in the bowels and the swollen lymph nodes. The lesions showed definite encapsulation, necrosis, caseation and calcification. Similar lesions were also detected in the mesenteric lymph nodes. In eight out of nine cases smears and sections were negative for *M. johnei*, whereas from four of the cases, which proved positive on cultural examination, non-pigmented variety of the organism was isolated.

Discussing the character of lesions in different groups with reference to the virulence and host resistance, the authors assumed that the pigmented variety of *M. johnei* was more virulent to sheep than the classical non-pigmented variety. (G. L. S.)

Lipid deficiency in the calf. M. R. LAMBERT, N. L. JACOBSON, R. S. ALLEN and J. H. ZALETEL (1954), *J. Nutrit.* **52**, 259-270

INVESTIGATIONS in the role of lipid in the nutrition were made by feeding 20 young dairy calves a lipid-free semi-synthetic milk diet which contained casein (lipid-free) 3.5 per cent, fat 0.0-3.0 per cent, salt 0.2 per cent, lecithin variable, lactose 5.0 per cent and vitamins. In addition, each calf received 80 mg. of crystalline auryomycin hydrochloride per day. Responses to various lipid supplements, such as hydrogenated soybean oil plus lecithin, crude soybean oil, butter oil, methyl-esters of fatty acids (Oleate 50 per cent, linoleate 50 per cent), lecithin, pork-liver fat and free fatty acids, were also evaluated.

Prior to feeding, the semi-synthetic milk diet was warmed to about 100°F. and vitamins were added. When lipids were used, they were added to the milk diet and the mixture was homogenized at 2500 lb. pressure.

Calves which received fat-free diet had retarded growth. They had long dry hair, excessive loss of hair from tail, back and neck, and diarrhoea. These symptoms disappeared when various lipids were included in the diet. Prompt recovery was brought by the addition of butter oil, hydrogenated soybean oil plus lecithin, and mixed methyl esters of oleic and linoleic acids.

Blood plasma 'Allen fat', total fatty acids, phospholipids and linoleic acid were significantly lower in the calves receiving lipid-free milk than in calves receiving lipids. Differences among the various dietary groups in blood plasma, linoleic acid and arachidonic acid contents were small. (*B. S. G.*)

Seasonal variation in quality of eggs as measured by physical and functional properties. E. A. SAUTER, J. V. HARNS, W. J. STADELMAN and B. A. McLAREN, *Poult. Sci.* **33**(3), 519-524

THIS experiment was undertaken to study the effect of season of production on the physical measurements of eggs and the cooked products prepared from them.

White Leghorn and New Hampshire pullets hatched within two weeks of each other were used for the experiment. Two different diets, one producing light yolk and the other producing dark yolk, were fed to each breed. The eggs were stored at 72°F at 65-70 per cent relative humidity and the samples were removed from storage for experiment at weekly intervals for five weeks, the following measurements were made (i) albumen index, (ii) albumen score, (iii) yolk index, (iv) yolk colour and (v) pH (using glass electrode). After the above measurements, cakes were made of the eggs and the quality of the cakes was evaluated by measuring the volume, penetration, flavour, texture and grain.

Eggs laid from January to March were considered as winter eggs and those laid from May to July as summer eggs. Winter eggs were superior to summer eggs as regards albumen index, yolk index and albumen score. Even though eggs laid by New Hampshire were slightly superior to those of White Leghorn, this can be attributed to strain difference rather than to breed difference. The internal quality of eggs deteriorated from one to five weeks but the changes observed by pH measurements and yolk colour were not statistically significant, in storage or between seasons. But diet plays a definite role in yolk colour.

Volume, flavour and texture of cakes decreased in summer as compared to winter season. Cakes made from stored eggs were poorer than those from fresh eggs. As summer advanced, albumen index and yolk index decreased with increase in albumen score. pH also increased slightly perhaps due to poor shell quality and concomitant loss of CO₂. Flavour also was affected by storage.

No significant differences were observed in functional or flavour properties of fresh eggs, produced during the months January to July, but season did have an effect on the physical qualities of eggs. The winter eggs were significantly superior to summer eggs in their keeping quality for one to five weeks at 72°F, with respect to physical quality, functional properties and flavour. (T. S. K.)

Disappearance of the growth response of chicks to dietary antibiotics in an "old" environment. PAUL E. WAIBEL, O. J. ABBOT, C. A. BAUMANN and H. R. BIRD (1954). *Poult. Sci.* 33, (6) 1141-1146

THE authors describe experiments conducted in one environment over a three-year period. They found consistent growth responses to antibiotics for nearly two years, but during the third year, responses became inconsistent and negligible. Many variations in composition were introduced in the diets, in an attempt to produce maximum growth in the absence of antibiotic. During the first 20 months, 66 positive responses were recorded in 69 observations by the addition of penicillin or aureomycin and none of the various nutritional supplements fed during this period eliminated the response to antibiotics. The quantitative responses to the antibiotics tended to vary inversely with the growth of control groups. When the growth in the control group was relatively poor, the percentage increase due to the antibiotic was large and when growth in the control group was good, the improvement due to the antibiotic diminished. The dietary variations, therefore, played some part in the variability of response to antibiotics. The percentage increase in growth due to aureomycin ranged from 6 per cent to 39 per cent on different diets and a comparable variability was noted in the presence of penicillin between certain diets.

During the third year, the antibiotics failed to stimulate growth consistently. This lack of response might have been due to the change in the microbial balance with the decrease in the moisture in the room brought about by a change in cleaning practices. Another possibility is that the harmful bacteria had been eliminated through continued use of antibiotics. But, whatever may be the explanation, it is apparent that a decrease in the growth promoting effect of the antibiotic occurred in an environment continuously occupied by chicks. (S. B.)

Field study of the epidemiology and clinical manifestations of parasitic bronchitis in adult cattle. J. F. MICHEL and A. SHAND (1955). *Vet. Rec.* 67, (14)

THE authors describe and discuss 17 cases of outbreaks of husk in adult cattle and their histories, selected from a large number to illustrate the great diversity encountered. In the great majority of outbreaks the infection is said to be endemic on the farm, generally in a sub-clinical form. The various outbreaks have no simple factor in common. Whether any external factor renders the adult animals susceptible to infection does not emerge from this investigation, but inadequate nutrition also does not appear to be such a predisposing factor. Gradual exposure to infection is less dangerous than sudden exposure. The longer the animals remain unexposed to infection the more susceptible they become. The ultimate source of infection is the small number of larvae disseminated in the faeces of carrier animals and not those which persist on the ground through the winter. The indications are that the larvae do not persist on the ground even as long as five months. The small number of larvae disseminated by carrier animals may turn into a source of dangerous level of infestation on the ground in two ways: (i) by intervention of calves who become lightly infected but pass sufficient larvae in the faeces to raise the level of infestation of the pasture and (ii) directly, where the conditions are particularly favourable for the larvae. Lush ley pastures appear to represent a particularly favourable vehicle for the survival and transmission of the infection. The level of infection on the ground may remain dangerous even after an intervening hay cut has been taken.

The symptoms appear 12 days or more after exposure to heavy infection or 12 days or less after a move to after-math, or even without any obvious precipitating cause. The nature of symptoms of husk varies according to their severity. The most severely affected animals may either get cough or their sudden acute illness or even death may be the first sign of an impending out-break. The less severely affected animals often develop symptoms later and then only cough. A continuous range of symptoms of increasing severity from an occasional mild cough to acute respiratory distress with pulmonary oedema and emphysema closely resembles the condition known as fog fever. This fog fever syndrome, when associated with parasitic bronchitis, is most frequently seen in adults but may be found in young stock also. On its appearance the animal presents a picture of extreme distress, and conveys the impression that death might supervene at any moment from oxygen starvation. The other clinical manifestations are: cessation of feeding and drinking, depression in milk yield, abortion in the later stages of pregnancy and loss of weight and condition. Complete recovery is possible within three weeks but severely affected animals may remain desperately ill for months. (S. R. G. M.)

A study of the protein requirements of fattening feeder lambs. L. F. BUSH, J. P. WILLIAMS and F. B. MORRISON (1955). *J. Anim. Sci.* 14, 465-469

TWO hundred and ninety-seven feeder lambs were used in three experiments, spread over three years. Three levels of protein, viz. 10.0 per cent, 11.0 per cent and 11.8 per cent on the total ration basis were used every year. In addition, the effect of supplementation with various proportions of alfalfa hay to corn silage, the

basic roughage, was also studied. The concentrates used were shelled corn and linseed meal, the latter being varied from group to group to give the required protein percentages.

The lambs fed rations with about 11.8 per cent total protein made significantly more rapid gains but the carcasses were not, however, as fat as those fed rations containing 10.0 and 11.0 per cent protein. Between the last two groups, there was practically no difference.

Supplementing the various rations with either 0.75 lb. or 0.5 lb. of alfalfa hay daily per animal did not significantly affect the rate of gain. The feed cost per cwt. gain in weight was lowest with the 'silage alone' group and highest in the 0.75 lb. 'hay supplemented' group. However, as the dry matter intake was very high in the 'silage alone' group, and as the lambs offered 0.5 lb. alfalfa hay had slightly better degree of finish, the authors advocate that a small amount of hay may be fed when corn silage is the only roughage. (S. N. R.)

An investigation of antibody response in cattle vaccinated with the rabbit-passaged LA rinderpest virus in Korea. NAKAMURA, J., KISHI, S., KIUCHI, J. and REISINGER, R. (1955). *Amer J. vet Res.*, 16 (58), 71-75

IN this paper the authors briefly describe the results of serological investigations carried out in 1952 and 1953 on the animals that were vaccinated against rinderpest with LA (Lapinised-avianised) virus. In November and December 1952, 15,000 head of cattle were vaccinated and about the same number during the same period in 1953. Immunisation was done in South Korea for maintaining the immune zone below the 38th parallel.

In the 1952 investigation, serum samples were collected before vaccination from 151 animals, and from 91 out of these, after vaccination; antibody response shown by each of these animals was then investigated by means of complement fixation and virus neutralization tests.

Among 151 pre-vaccination serums, 146 (96.7 per cent) were negative, four (2.6 per cent) doubtful and only one (0.7 per cent) was positive in a low titre. In contrast, among 92 post-vaccination serums, the development of the complement fixing antibody was demonstrated in 57 (62.6 per cent) of the vaccinated animals, 7 (7.7 per cent) proving doubtful and 27 (22.7 per cent) negative. The virus neutralization antibody was found in all the 10 animals positive by the complement fixation test, in 5 of the 6 giving a doubtful C.F. reaction, and in 20 of the 27 animal proving negative by the C.F. test.

In the 1953 trials, all the serums from 100 animals from which pre-vaccination samples were collected gave negative C.F. titre. Forty-eight animals whose post-vaccination serums were collected gave positive C.F. test in 30 animals (64.5 per cent).

Immune response, following vaccination with LA virus as indicated by the development of virus neutralization and complement fixation antibodies, was proved

in the serum of 82 out of 91 (90.1 per cent) animals in 1952 while the complement fixation antibody was demonstrated in 64.5 per cent of the 48 vaccinated animals in 1953. Development of the virus neutralization antibody was far more regularly demonstrated than that of the complement fixing antibody. For indicating the immune response the virus neutralization test can be said to be more reliable than the complement fixation test, although neither of them is a correct indicator of true immunity. The complement fixation test, however, has a great advantage in application for mass study in a short time of the evidence of development of immunity. (M.S.M.)

Use of rabbit-passaged strain of the Nakamura LA rinderpest virus for immunising Korean cattle. REISINGER, C., MUN, C. P. and LEE, N. S. (1954). *Amer. J. vet. Res.* **15** (57), 554-60

THE authors have described about the utility of Lapinised-avianised (IA) vaccine for immunising Korean cattle against rinderpest. Lapinised virus Nakamura III strain was found very pathogenic for the hypersusceptible Korean calves. Therefore, the authors have used LA virus which was found quite suitable for immunising Japanese calves that have a susceptibility to the Lapinised virus comparable to that evidenced by Korean calves. Their experiments have proved that LA virus is less pathogenic to rabbits than the Lapinised virus. But on serial passage in rabbits the pathogenicity increased and mortality rate exceeded 85 per cent which is comparable to that observed in rabbits infected with the original Lapinised virus.

In two preliminary experiments, four Korean calves were inoculated with the original LA virus received from Tokyo; 5 c.c. of a 1:500 suspension of embryo spleen produced only a slight thermal reaction and the animals were found to have acquired solid immunity on challenge by the bovine rinderpest virus. It was thought that LA virus would regain its original pathogenicity for calves on serial passages in rabbits but there was no indication of this as it was found quite non-pathogenic to 120 calves that had been inoculated in the laboratory with rabbit-passaged virus of high concentration, and they survived the inoculation without any untoward reaction and revealed complete resistance to the challenge.

More than 30,000 cattle were safely vaccinated in Korea during 1952 and 1953 with LA virus. No adverse reaction was observed in any of the vaccinated animals and more than 90 per cent revealed the immune response by production of complement fixation and virus neutralizing antibodies. The authors are of the opinion that the Nakamura LA strain of rinderpest virus gives a safe and effective immunity to Korean cattle and will be quite effective in immunising all species of hypersusceptible animals against rinderpest. (M.S.M.)

On the invasion of the central nervous system by nematodes. I. The incidence and pathological significance of nematodes in the central nervous system. (1955) J. F. A. SORENT, *Parasitology*. 45, 1 and 2, 31-40.

THE paper reviews the available literature on the incidence and pathological significance of nematodes in the central nervous system. It has been observed that a large number of nematodes invade the central nervous system and cause a variety of nervous symptoms. Living specimens of different nematodes have been recovered from the meningeal spaces and tissues of the brain and spinal cord by various workers. These nematodes belong to the orders: Ascaridoidea, Filarioidea, Trichuroidea, Strongyloidea, Matastronygloides, Rhabditoidea and Dioctophymatidae.

The pathological effect caused by these nematodes vary to a great extent depending upon the size, mobility and the activity of the parasite. The pathological changes observed are haemorrhagic, degenerative or proliferative. These are all the direct effects of nematodes on the central nervous system and are mainly due to the traumatic effect of the parasite on the central nervous system depending upon its size.

Several parasites and their involvement in causing the pathological changes have been mentioned. It has been stated that *Setaria* spp. (Filarioidea), in cattle and horses, cause the disease known as *Kumree* where in the parasites cause softening and congestion of the spinal cord. Similarly lumbar paralysis in goats, has been attributed to the invasion of central nervous system by the larvae of *Setaria digitata*.

The symptoms vary according to the degree of invasion of the parasite on the central nervous system. There are nervous symptoms such as epilepsy. Nervous symptoms have also been described in somatic nematode infections. But no explanation could be given as to the occurrence of these symptoms and it remains rather obscure, though one school of thought considers that these symptoms are, probably, of allergic origin.

This argument is based on the evidence that certain toxins are elaborated by some parasites such as *Trichinella*. It has also been experimentally proved that infection of the larvae of *Ascaris suum* induces a state of hypersensitivity, with allergic symptoms. The injection of ascaris extracts in animals already sensitised caused certain changes in the central nervous system. So, in all probability, these changes in the nervous system may be due to the allergic reactions brought about by ascaris antigen.

It has been proved that these nematodes also transport viruses to the different parts of the central nervous system and thus act as a carrier of virus. It has been observed that *Ascaris suum* transmits a virus which causes infectious paralysis in pigs. However, there is no possibility of poliomyelitis being transmitted by these nematodes, as observed by many workers. It is also doubtful whether there is any possibility of *Setaria digitata* transmitting the virus of Japanese B. encephalitis. (V.V.S.)

The dilution of semen with yolk of different breeds of poultry. (Zur Sperma verdünnung unter Verwendung Von Eidottern Verschiedener Hühnerrassen.)
AFHNELT E. AND BROCKMANN, P. (1955). *Dtsch. Tierärztl. Wschr., Beil. Fortpfl. U. Bes. der Haustiere*. V (8), 69-72

RESULTS are presented of 'in vitro' and 'in v' trials carried out on goat semen using yolks of different poultry breeds in the dilutor. The breeds tried were, *New Hampshire*, *Sussex*, *Leghorn*, and *Italians*. The sperm dilutor employed was the Spermasol, a German proprietary preparation containing 30 per cent fresh egg yolk. A dilution rate of 1:4 was kept throughout. From three adults and one young buck, 15 ejaculates per buck were taken for trial. Evaluation was done on the basis of average percentage of progressively motile and live sperms found when kept in the dilutors containing different yolks.

A distinct overall buck to buck difference was noticed in the first instance. Semen kept in dilutor containing yolk of *New Hampshire* gave the best results (70 per cent progressive motility upto 96 hours and longevity upto 185 hours) while the same in *Italians*, the worst (70 per cent progressive motility upto 67 hours and longevity upto 139 hours only).

Out of the 209 first inseminations carried out with semen preserved in the *New Hampshire* yolk dilutor, the percentage of non-returns was 85 as opposed to 76 per cent in the case of 205 like inseminations with the *Italians* yolk dilutor. The respective percentages of kiddings in the two dilutors were 85 and 74 with 205 and 199 inseminations. In the former, the rate decreased from 91 to 75 per cent while in the latter, from 85 to 60 per cent with the ageing of sperm from 0-48 hours. The authors, though unable to throw light on their results, suggest that the yolk of *New Hampshire* may be tried with profit in dilution and preservation of bovine semen. (S.S.P.)

REVIEW

GAIGER AND DAVIES VETERINARY PATHOLOGY AND BACTERIOLOGY

By G. G. O. DAVIES

(Published by Bailliere, Tindall and Cox Ltd., Fourth Edition, 1955, pp. 804,
Price 42 s.)

THE fourth edition of this well-known book has appeared some nine years after the third edition, which was reprinted twice. The present edition retains the get-up and the general format of the previous edition. As before, it is divided into three parts—general pathology, bacteriology and pathology of specific diseases, and special pathology and includes an appendix of over 40 pages on technique. The part dealing with specific diseases includes, *inter alia*, chapters on spirochaetes, pathogenic fungi, and protozoon parasites. The text material as well as the 200 illustrations of the previous edition have been retained, but changes have been made in the text to bring it up-to-date. The two chapters on protozoal diseases have been exhaustively revised.

Since it became available in India, 'Gaiger and Davies' has been increasingly used as a text-book for veterinary pathology and bacteriology. It covers more or less completely, in a single volume of reasonable size, the syllabus prescribed for these subjects by Indian Universities and its style and simple language have added to its popularity with the students. However, it is disappointing to note that certain diseases and disease conditions which are of specific interest to this country, and the knowledge acquired in respect of them in comparatively recent years, have received scant attention in this book ; and so our teachers and students have to seek the required information from other sources.

Dr. Davies has promised to recast the book completely in the next edition to make it still more suitable for the needs of veterinary students. It is hoped he will take necessary steps to incorporate in the new edition as much practical, laboratory and field experiences from tropical and sub-tropical countries as possible. (R.N.M.)

AN ANNOUNCEMENT
JOHN MURRAY TRAVELLING
STUDENTSHIP IN OCEANO-
GRAPHY AND
LIMNOLOGY

The Council of the Royal Society is prepared to receive applications for the John Murray Travelling Studentship in Oceanography and Limnology. Particulars and application forms may be obtained from The Assistant Secretary, Royal Society, Burlington House, Piccadilly, London, W1.

THE PROGNOSTIC VALUE OF LEUCOCYTIC BLOOD PICTURE IN TUBERCULOUS CATTLE

By A. F. HATHOOT, A. H. GOBBA, and I. H. MOUSTAFA, Animal Breeding Department, Faculty of Agriculture, Cairo University, Giza, Egypt

(Received for publication on February 14, 1955)

FOR the diagnosis and prognosis of tuberculosis, close co-operation is necessary to correlate the blood changes with the clinical findings. For prognostic purposes the sedimentation rate, the schilling haemogram, and to a less extent a careful analysis of the leucocytic count are of major value.

Strohle [1950] concludes that tuberculosis in cattle does not appear to influence the sedimentation rate. Muller [1943] reviews all aspects of the blood changes which may be found in human tuberculosis. Thijn [1949] concludes that the morphological blood test may be of great help in finding animals having active tuberculosis.

The tuberculin test gives no information about the activity of the focus [Topley and Wilson, 1949]. A positive reaction does not distinguish between infection and clinical disease. So our attention is drawn to the leucocytic changes in blood hoping to find a significant aid in judging such tuberculous cases.

EXPERIMENTAL

Prior to the tuberculin test, samples of blood were taken for examination from cows and bulls belonging to the Faculty of Agriculture, Giza. 10 ml. of blood was drawn from the jugular vein into a sterile receptacle containing 20 mg. sodium fluoride as an anticoagulant. The haematological examination was carried out at once. Neubauer haemocytometer was used for white cell count. Smears prepared by 'slide and cover method' and stained by the panoptic method of Pappenheim adopted by Piney [1931] were examined for differential leucocytic count, schilling haemogram, arneth index as modified by Cooke, and monocyte/lymphocyte ratio.

The intradermal tuberculin test was performed on the animals under investigation. Twenty-five tuberculin-negative and apparently healthy animals were considered to represent their normal haemogram. Some of the positives were slaughtered at the abattoir; ten of them showed pulmonary lesions and were tabulated under group I and eight were found to be affected by generalized tuberculosis; these were tabulated under group II. Koch's bacilli were easily demonstrated in smears taken from the lesions. The data previously obtained from these positive cases, were compared with the normal haemogram.



RESULTS AND DISCUSSION

1. *Tuberculin-Negative Cases*A. *The white cell count*

In apparently healthy adult animals under discussion the white blood corpuscles ranged between 6,800 and 14,400 with an average of 10,816 per cu. mm. Delaune [1939] records an average of 10,225 w.b.c. per cu. mm. for adult animals between the age of 3 and 6.5 years. Storch [1901] records 15,739 w.b.c. per cu. mm. for calves, 11,614 w.b.c. per cu. mm. for young cattle, and 8,241 w.b.c. per cu. mm. for cows.

TABLE I

Apparently healthy tuberculin-negative adult cows and bulls (total and differential Leucocytic count)

No.	W.B.C.	Young	Neutr.		Total	Eos.	Bas.	Lym.	Mon.
			band	mature					
1	7-200		2.5	24	26.5	0.5	0	65.5	6.5
2	11-000		1.5	17.5	19	5.0	0	71.5	4.5
3	7-400		4	16	20	1	0	67	4
4	10-800		8	32	40	0	0	52	8
5	11-000		3	16	19	5	0	70	6
6	6-800		2	16	18	5	0	70	7
7	14-200		4	22	26	1	0	67	4
8	9-00		.5	19	24	5	0	66	5
9	11-600		3.5	22.5	26	3	0	70	1
10	9-00		5.5	22.5	28	0	0	70	2
11	14-000		1.5	18	19.5	5.5	0	72.5	2.5
12	9-400		3	25	28	4	0	66	2
13	12-200		6	23	29	1.5	0	68.5	1
14	11-600		3	17.5	20.5	0.5	0.5	76	2.5
15	12-000		2.5	22.5	25	2	2	67	4
16	8-800		4	17.5	21.5	5.5	0	67.5	5.5
17	9-400		3.5	28.5	32	8	0	53	7
18	8-200		5.5	21	26.5	2	0	66	3.5
19	13-800		4	21	25	4	0.5	66	4.5
20	9-600		2.5	22	24.5	2	0	68	5.5
21	13-200		6.5	24	30.5	6	0	56.5	7
22	12-000		7	23	30	4	0	63	3
23	12-000		6	33	39	8	0	47.5	5.5
24	11-800		5	26	31	4	0	62	3
25	14-400		4	19.5	23.5	9.5	0	60	7
Maximum	14-400		8	33	40	9.5	2	76	8
Minimum	6-800		1.5	16	17.5	0	0	47.5	1
Average	10-816		4.16	21.88	26.63	3.68	0.12	64.7	4.46

B. *Differential leucocytic count*

The neutrophiles ranged between 17.5 per cent and 40.0 per cent with an average of 26.63 per cent, while the lymphocytes gave a maximum of 76 per cent, a minimum of 47.5 per cent and an average of 64.7 per cent. It is clear that the lymphocytes always outnumber the neutrophiles in the normal blood picture. The eosinophiles ranged from zero to 9.5 per cent with an average of 3.68 per cent. The basophiles were not demonstrated in majority of the cases under discussion with the exception of cases No. 14, 15 and 19 which gave 0.5 per cent, 2 per cent, and 0.5 per cent respectively. The monocytes ranged from 1 per cent for the minimum to 8 per cent for the maximum, with an average of 4.46 per cent.

It is interesting to record some of the findings reported by different investigator for purpose of comparison.

Author	Animals	Neutro	Eosin.	Bas.	Lymph.	Mono.
Dimmock and Thompson (U.S.A.)	Adult Cattle	13-45.8 (30.4)	3-8-26.6 (13.15)	1-1-2 (0.59)	31-76 (54.2)	0-2-3-3 (1.4) per cent
Kohanwa (Berlin)	do.	27-9-40.4 (33)	6-1-16.8 (10.9)	0-0-3 (0.1)	44-6-56.4 (51.7)	22-6-2 (4.3) per cent
Fraser (England)	do.	16-2-56.4 (28.4)	1-2-25.4 (9.9)	0-1-4 (0.1)	29-76.4 (54.7)	1-8-18-2 (6.7) per cent
Findings in this work	do.	17.5-40 (26.63)	0-9.5 (3.68)	0-2 (0.12)	47.5-76 (64.7)	1-8 (4.46) per cent

N.B. The figures in the statement show the range while those in the brackets denote averages.

C. *Schilling haemogram* (Table I)

Only mature and band forms of neutrophiles were present in the blood; myelocytes and young forms were not met with. Band forms ranged from 1.5 per cent to 8 per cent with an average of 4.16 per cent while mature forms gave 16 per cent for the minimum, 33 per cent for the maximum, and 21.78 per cent for the average.

Fraser [1929-30] records the index separately counting the myelocytes, young and band forms in 100 neutrophiles. For adult cattle he records 0.1 per cent young forms, 3.5 per cent band forms, and 96.3 per cent mature cells.

D. *Arneth Index as modified by Cooke* (Table II)

In applying the Arneth Index as modified by Cooke to these animals a hundred neutrophils were counted and classified accordingly. It is found that the majority of the cells lie in Classes I and II with a few cells lying in Class III and a very few or none in classes IV and V as shown in Table II.

TABLE II
Apparently healthy tuberculin-negative cows and bulls (Arneth Index as modified by Cooke)

Serial No. coinciding Table I	I	II	III	IV	V
1	65	36	7	2	0
2	38	35	27	0	0
3	37	39	17	5	2
4	30	50	17	3	0
5	33	44	21	2	0
6	30	48	16	6	0
7	49	30	15	5	1
8	27	43	30	0	0
9	20	50	30	0	0
10	21	37	30	0	3
11	37	38	22	3	0
12	34	30	30	5	1
13	10	30	40	11	3
14	34	30	32	4	0
15	46	32	16	5	1
16	42	28	28	2	0
17	53	42	4	1	0
18	40	50	10	1	1
19	40	43	16	1	0
20	20	46	34	0	0
21	35	36	25	4	0

TABLE II—*contd.*

Apparently healthy tuberculin-negative cows and bulls (Arneth Index as modified by Cooke)

Serial No. coinciding Table I	I	II	III	IV	V
22	22	54	20	4	0
23	8	38	40	12	2
24	24	53	21	2	0
25	22	44	22	12	0
Maximum	35	54	40	12	3
Minimum	8	28	4	0	0
Average	32.68	40.48	22.8	3.6	0.56

Simpson [1929] gives the following for adult cattle

74	20	6	0	0
76	20	4	0	0
84	14	2	0	0
73	23	3	0	0
73	21	4	0	0

E. Monocyte-lymphocyte ratio (Table III)

The monocyte/lymphocyte ratio ranges between 1 : 6.5 and 1 : 70 with an average of 1 : 20.4.

Dunlop and Melville [1930] state that in health, the ratio between neutrophils and lymphocytes is less than the ratio between lymphocytes and monocytes.

TABLE III

*Apparently healthy tuberculin-negative cows and bulls
(the monocyte/lymphocyte ratio)*

Serial No. Coinciding Table I	W.B.C.	Lym. (per cent)	Mon.	Lym. No.	Mon. No.	M/L ratio
1	7.200	65.5	6.5	4716	468	1:100.07
2	11.000	71.5	4.5	7865	495	1:15.8
3	7.400	67	4	4958	296	1:16.75

TABLE III—*contd.*

*Apparently healthy tuberculin-negative cows and bulls
(the monocyte/lymphocyte ratio)*

Serial No. coinciding Table I	W.B.C.	Lym. per cent	Mon.	Lym. No.	Mon. No.	M/L ratio.
4	10-800	52	8	5616	864	1:16-5
5	11-000	70	6	7700	660	1:11-6
6	6-800	70	7	4760	476	1:10
7	4-200	67	4	2514	568	1:17-8
8	9-000	66	5	5940	450	1:13-2
9	11-600	70	1	8120	116	1:70
10	9-000	70	2	6300	180	1:35
11	14-000	72-5	2-5	10150	350	1:28-7
12	9-400	66	2	5204	188	1:27-7
13	12-200	68-5	1	8357	122	1:68-5
14	11-600	76	2-5	8816	290	1:30-5
15	12-000	67	4	8040	480	1:16-8
16	8-800	67-5	5-5	5940	484	1:12-3
17	9-400	52	7	4888	658	1:7-35
18	8-200	66	3-5	5412	287	1:18-8
19	13-800	66	4-5	9108	621	1:14-61
20	9-600	68	5-5	6528	528	1:12-4
21	13-200	56-5	7	7458	924	1:8-1
22	12-000	63	3	7560	360	1:21-0
23	12-000	47-5	5-5	5500	660	1:8-35
24	11-800	62	3	7316	354	1:20-6
25	14-400	60	7	8640	1008	1:8-6
Maximum						1:6-5
Minimum						1:70-0
Average						1:20-4

II. Tuberculin Positive Cases

A. The white cell count (Table IV)

Group I. Case No. 10 showed slight leucocytosis recording 11,400 per cu. mm., while the remaining cases showed numbers fluctuated between 6,200 and 10,200 which was within the normal.

Group II. Four cases (No. 14, 16, 17 and 18) showed slight leucocytosis, the count was 14,200, 13,800, 16,000 and 15,600 respectively. The count in the other four cases was within the normal. Medlar and Kastlin [1927] state that leucocytosis is the rule in cases not showing clinical improvement.

B. The differential count (Table IV)

Group I. The neutrophiles ranged between 10 and 30 per cent which was within the normal range. The eosinophiles ranged between 2 and 9 per cent which was within the normal. The basophiles were absent in all cases except case No. 2 which recorded 2 per cent. The lymphocytes showed an increase in four cases (No. 2, 3, 4 and 10); the count was 78, 84, 73 and 73 per cent respectively, the other six cases showed counts within the normal limit. The monocytes recorded an increase in six cases (No. 1, 2, 3, 4, 7 and 9); the count was 7, 7, 6, 5, 6 and 8 per cent respectively, the other four cases recorded counts within the normal limit.

Group II. The neutrophiles recorded an increase in three cases; it showed 45, 75, and 41 per cent for No. 11, 17 and 18 respectively. The eosinophiles ranged from 1 to 10 per cent which was within the normal. The basophiles were totally absent in all the cases. The lymphocytes showed tendency to decrease where the neutrophiles were high; it recorded 38, 16 and 39 per cent for cases No. 11, 17 and 18 respectively. The monocytes showed an increase in all the cases with the exception of No. 12 which showed 2 per cent, the remaining cases ranged between 5 and 24 per cent.

Piney [1931] states that lymphocytes are present in the early stages of the disease in cases with good prognosis and that the absence of lymphocytosis, presence of neutrophilia and occurrence of leucocytosis are all bad signs. In miliary tuberculosis there is relative and absolute neutrophilia, but the number of leucocytes may be normally reduced or increased.

C. Schilling Index (Table IV)

Group I. The young forms were totally absent, the band forms ranged between 2.5 and 6 per cent and the mature forms ranged between 7.5 and 24.5 per cent. The schilling index showed no deviation from the normal in cases of this group.

Group II. The young forms were totally absent in the eight cases under study. The band forms recorded an increase in all the cases and ranged between 9 and 26 per cent. The mature forms were within the normal range except in No. 17 which showed an increase up to 49 per cent. The data point to the fact that neutrophilia

with left displacement took place in advanced stage of the disease. Stasney and Feldmann [1938] attempted to produce a leukomoid reaction in calves by inoculation of a virulent strain of *Mycobacterium tuberculosis*. Results provoked leucocytic increase mainly due to neutrophils, there was decrease in number of lymphocytes and over stimulation of myeloid tissue and immature cells were demonstrable.

TABLE IV

Tuberculin-positive cows and bulls (total and differential leucocytic count)

Name of animal	W.B.Cs.	Young	Neutr.		Total	Eos.	Bas.	Lym.	Mon.
			band	mature					
Group I. Pulmonary T.B.									
Bent Olga	7-400	0	4-5	20-5	25	8	0	60	7
Zahiah	10-200	0	2-5	7-5	10	3	2	78	7
Sananeer	7-000	0	2-5	15-5	18	2	0	84	6
Souhair	8-000	0	4	14	18	3	0	73	5
Bent Darl	10-000	0	5-5	24-5	30	7	0	60	3
Florine	6-2000	0	5	21	26	3	0	68	3
Fibiana	9-400	0	3	17	20	9	0	65	6
Emeline	8-400	0	5	18	23	8	0	61	2
Darlington	9-000	0	6	18	24	6	0	60	8
Ibn Mabel	11-400	0	2-5	11-5	14	9	0	73	4
Group II. Generalized T.B.									
Sahiah	5-600	0	20	25	45	3	0	38	14
Hommos	6-400	0	9	15	24	9	0	65	2
Ibn Hana'	8-400	0	14	19	33	3	0	59	5
Mabel	14-200	0	13	18	31	10	0	53	24
Gessy	7-200	0	13-5	24-5	38	1	0	55	6
Nanit	13-800	0	17	17	34	3	0	61	6
Bent sehda	16-000	0	26	49	75	0	0	16	9
Ibn Darling	15-600	0	18	22	48	1	0	39	12

D. *Arneth Index as modified by Cooke* (Table V)

Group I. Cells under classes I and II ranged between 50 and 70 per cent which was within the normal range in all cases except in one case (No. 8) which recorded slight increase up to 77 per cent and so a shift to the left took place in this case only.

Group II. Cells under classes I and II recorded an increase which ranged between 85 and 97 per cent in eight cases. A shift to the left took place.

According to Ponder and Flint [1927], Arneth believes that this left handed deflection occurs in tuberculosis only. When it occurs in other infections, he thinks that these are to be regarded as superimposed on a tuberculosis basis. On the other hand Cooke [1914] states that the polymorphonuclear picture is changed in the great majority of cases, dependent on microbic infections. He emphasises the occurrence of a left handed deflection in tuberculosis as a constant occurrence but insists that it is not characteristic of that disease alone. If the case becomes worse, the left handed shift becomes greater, but if the case tends towards recovery the picture assumes its normal appearance.

TABLE V

Tuberculin-positive cows and bulls (Arneth Index as modified by Cooke)

Name of animal	I	II	III	IV	V
<i>Group I. Pulmonary T.B.</i>					
Bent Olga	29	38	29	4	0
Zahiah	30	35	30	5	0
Sananeer	28	37	27	8	0
Souhair	25	25	30	15	5
Bent Darlington	30	40	20	10	0
Florina	20	50	30	0	0
Fibiana	25	30	30	10	5
Emeline	28	49	18	5	0
Darlington	17	46	30	12	5
Ibn mabel	29	38	29	4	0
<i>Group II. Generalized T.B.</i>					
Sabiah	38	47	13	2	0
Hommos	40	57	3	0	0
Ibn Hana'	53	41	6	0	0
Mabel	45	45	10	0	0
Gessy	35	51	15	0	0
Nanit	38	57	5	0	0
Bent Sahdah	48	55	7	0	0
Ibn Darlington	40	50	10	0	0

E. The monocyte/lymphocyte ratio

Group I. Eight cases out of ten gave ratio higher than the normal average (1:20-4). It was 1:8-6, 1:11-1, 1:14, 1:14-6, 1:20, 1:10-83, 1:7-5 and 1:18-2 respectively. Only two cases (No. 6 and 8) gave ratio within the normal range, it showed 1:22-7 and 1:30-5 respectively (Table VI).

Group II. Of eight cases, seven gave ratio higher than the normal average, it recorded 1:2-7, 1:11-8, 1:2-2, 1:9-17, 1:10-17, 1:1-8 and 1:3-25 respectively. The one case that gave ratio within the normal range was case No. 12 which recorded 1:32-6 (Table VI).

TABLE VI
Tuberculin-positive adult cows and bulls (the monocyte /lymphocyte ratio)

Name of animal	W.B.C.	Lymph. per cent	Mono. per cent	Lymph. No.	Mono. No.	M/L ratio
<i>Group I. Pulmonary T.B.</i>						
Bent Olga	7-400	60	7	4440	518	1:8-6
Zahiah	10-200	78	7	7950	714	1:11-1
Sananeer	7-000	84	6	5880	420	1:14
Souhair	8-000	73	5	5840	400	1:14-6
Bent Darling	10-000	60	3	6000	300	1:20
Florine	6-200	08	3	4210	186	1:22-7
Fibiana	9-400	65	6	6100	564	1:10-83
Emeline	8-400	61	2	5120	168	1:30-5
Darlington	9-000	60	8	5400	720	1:7-5
Ibn Mabel	11-400	73	4	8320	456	1:18-2
<i>Group II. Generalized T.B.</i>						
Sahiah	5,600	38	14	2125	782	1:2-7
Hommos	6,400	65	2	4150	128	1:32-5
Ibn Hana'	8,400	59	5	4950	340	1:11-8
Mabel	14,200	53	24	7500	3498	1:2-2
Gessy	7,200	55	6	3950	432	1:9-17
Nanit	13,800	61	6	8400	828	1:10-17
Bent Sehda	16,000	16	9	2560	1440	1:1-8
Ibn Darling	15,600	39	12	6100	1872	1:3-25

It is clear that the ratio was markedly higher in cases of Group II than that of Group I which also was comparatively higher than the normal average. The data point out the severity of infection in cases of Group II and that such cases were going unfavourable. The two cases of Group I and the one case of Group II, however, did not give high ratios: on the contrary, the ratios were within the normal range. This might be explained that the infection remained quiescent or toxins liberated were not of sufficient virulency to cause a reaction.

Cunningham, Sabin and co-workers [1925] lay great stress on the importance of the M/L ratio. They conclude that the normal ratio in the rabbit is 1:2.97 and in experimentally infected animals where the reaction was constantly unfavourable the ratio rose to 1:0.79 whereas in favourable cases it lowered to 1:3.56. They believe that this ratio is an important law in connection with the disease.

Dunlop and Melville [1930] state that the blood picture in tuberculosis differs from that of health and the difference is not entirely due to secondary infection. It is mentioned above that in health the ratio between the neutrophils and lymphocytes is less than the ratio between the lymphocytes and monocytes. This picture is reversed in tuberculosis and the more it deviates from the normal, the worse is the prognosis. If neutrophils be taken as expression of activity, the lymphocytes of resistance or healing, and the monocytes in certain circumstances of new tubercle formation and in others of healing, then by following the leucocytic picture week by week, it is possible that a very accurate index of the progress of the disease, and of the patients reaction to it may be obtained.

SUMMARY

1. The twenty-five apparently healthy cases under study showed that the average of the white cell count was 10,816 per cu. mm. The lymphocytes and the neutrophils averages were 64.7 and 26.63 per cent respectively; so the lymphocytes outnumber the neutrophils. The averages of the basophils and the eosinophils were 0.12 per cent and 3.68 per cent respectively; while the monocytes average was 4.46 per cent; the basophils being the scantiest of all cells. As regards Schilling index no young cells were demonstrated and the average of band forms was 4.16 per cent. On applying the Arneth index, it was found that cells under classes I and II outnumbered those of classes III, IV and V. The average of monocyte/lymphocyte ratio was 1:20.4.

2. In the tuberculin-positive cases, the data collected in this work and the different views established by the various workers showed that any or all of the blood elements may be affected in tuberculosis. It seemed that the leucocytic picture was dependent on the phase of the active tubercular process as well as on the resistance of the animal. Different workers stated that leucocytosis, leucopenia, or normal count may be met with in tuberculosis and that such variation depended on the severity of the disease. In this work leucocytosis was encountered in four cases of generalized tuberculosis (Group II). Normal counts were shown by the remaining cases in both groups. In pulmonary tuberculosis (Group I) slight lymphocytosis took place in four cases and monocytosis in six cases, while no deviation from

the normal was present in the other cells. The Schilling index showed no displacement while the Arneth index illustrated a left shift in one of the ten cases. The monocyte/lymphocyte ratio was high in pulmonary tuberculosis except in two cases. In generalized tuberculosis (Group II) neutrophilia was evident in three cases and monocytosis in seven. Lymphocytes showed a tendency to decrease in the presence of neutrophilia. A deflection took place in all cases, the band forms ranged between 9 per cent and 26 per cent which was higher than the normal average. A shift to the left occurred in all cases. The monocyte/lymphocyte ratio was comparatively higher in all cases of this group than in Group I.

3. It was found that the blood elements in cases of generalized tuberculosis were more affected; leucocytosis with neutrophilia occurred. In all cases, Schilling index showed a displacement and the Arneth index demonstrated a left shift. The monocyte/lymphocyte ratio was markedly high. On the other hand, slight lymphocytosis and monocytosis occurred, in pulmonary tuberculosis; these were favourable signs in the pulmonary type of the disease.

4. The blood picture was comparatively prognostic for tuberculosis.

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OBSERVATIONS ON THE TREATMENT OF FOOT AND MOUTH DISEASE*

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(Received for publication on July 23, 1955)

THE occurrence of the foot and mouth disease in India is widespread, though in a much less virulent form in the indigenous cattle. The economic loss due to reduced working capacity, and mortality resulting from an outbreak in a herd or in a village is keenly felt by the cultivator, especially when he is busy with agricultural operations. Effective control measures to eradicate it, or even to protect the animals against the disease, however desirable or necessary, are not fully practicable at present in this country. So attempts are often made to treat the cases by using chemical substances, indigenous medicines, patent drugs, etc. Some private agencies have produced what they claim as "Cure" for foot and mouth disease and advertise their products for sale. Reports have also appeared of patent drugs having prophylactic action and curative effect on the infection. Such a drug would certainly find a market as cultivators would purchase it, when the disease prevails in their area. As to the actual effect of the drug they may not be sure, but they would certainly be tempted to purchase and try it.

This article describes the experimental treatment carried out with some of the patent drugs and other substances claimed to be effective against the disease. From the results of the experiments it was evident that none of them was effective either as a curative or as a preventive. In fact, the object of undertaking the experimental treatment was to find out whether the claim, often made by the producers or agents, for the drug being a cure for the disease was justified or not.

A review of the literature on the subject shows that a large number of chemical substances, dye stuffs and other preparations were tried by various workers. Walker and Taylor [1926] reported success in treating experimental infection in calves by intravenous injection of Lugol's Iodine solution. However, experiments made on guinea-pigs by Maitland [1928] proved that administration of iodine did not affect the onset of the disease. Similarly, Andrews *et al.*, [1939] described experimental trial of iodine both on guinea-pigs and cattle and arrived at the conclusion that iodine did not exercise any noticeable influence in restraining or inhibiting the development of foot and mouth disease in cattle. Trypan blue and intramine were tried for the treatment of the disease in India by Stirling [1927]. It was observed that such treatment did not prevent infection but that it considerably attenuated the course of the disease. Galloway [1931] made a very large number of experiments using dyes and other chemicals. But none of these had any definite effect in modifying the course of the infection.

*Paper read at the Indian Science Congress held at Lucknow in January, 1953.

MATERIAL AND METHODS

With a view to assessing the therapeutic value in the treatment of the disease, the following recommended drugs and other methods were tried.

1. Aphtisine-131
2. Lacto-therapy
3. Marking nuts
4. 'Mokhur'
5. 'Wilco'

In all these controlled experiments, foot and mouth disease virus type strain Vallee 'O' was used for giving the infection, and depending upon the availability, either hill bulls or guinea-pigs were taken up for treatment. Tests were carried out in each case to determine the effect of the drug, both as a prophylactic and as a curative. Some of the drugs were supplied by the agents or manufacturers, while others, the beneficial effect of which was reported, were obtained locally for the test.

Aphtisine-131

This product was supplied by Messrs Mohendra & Co., Bombay. It appeared to be a biological product of Poland Bordet Laboratories, Paris, and was claimed to be a curative and preventive for foot and mouth disease. The full details and the method of preparation were not given. The following experiment was carried out :

(a) Three animals (two hill bulls and a calf) were given subcutaneously 10 and 5 c.c. of Aphtisine-131 respectively, followed 24 hours later by infection with the disease virus type 'O'. Two of them were given a second dose also.

(b) Three animals (two hill bulls and a calf) were given the drug and the infection of virus simultaneously.

(c) Three animals (two hill bulls and a calf) were given virus infection first, followed 24 hours later by a dose of the drug.

Two healthy hill bulls receiving virus only were kept as controls.

Results. The treated animals reacted severely showing both primary and secondary lesions. The drug appeared to have no beneficial effect against artificial infection with the disease virus type 'O' which is the most commonly prevalent type in this country. It was doubtful if the drug would be effective against infection with the



other two types and so in view of the high cost of animals, it was not considered advisable to undertake any further experimentation. Details are given in Table I.

TABLE I
Summary of treatment with Aphthisine-131

Serial No.	Animal No.	Date of infection		Reaction	Remarks
		Aphthisine-131	Virus Type 'O'		
1	Hill bull No. 13	9-10-50	10-10-50	Reacted severely	
2	Bull calf No. 152	do.	do.	do.	Received 2 doses of the drug
3	Hill bull No. 157	do.	do.	do.	9th and 13th October
4	Hill bull No. 12	10-10-50	do.	do.	Died of foot and mouth disease on 20-10-50
5	Hill bull No. 90	do.	do.	do.	
6	Bull calf No. 108	do.	do.	do.	
7	Hill bull No. 1	11-10-50	do.	do.	
8	Hill bull No. 38	do.	do.	do.	
9	Heifer calf No. 451	do.	do.	do.	
10	Hill bull No. 40	—nil—	do.	do.	
11	Hill bull No. 7	—nil—	do.	Not reacted	Probably immune

Lacto-therapy

Milk cure or lacto-therapy was undertaken as an experimental trial with reference to an abstract of an article by Borosovich [1946] who has claimed that complete immunity is produced against foot and mouth disease by milk treatment and lactation is also restored speedily. The method recommended is to boil skim milk for five minutes, then cool to 37°C and inject intramuscularly 80 to 100 c.c. daily for three days in succession.

Experiment: (a) Four hill bulls were injected intramuscularly with boiled skim milk on three successive days, each receiving 80 c.c. on the first day and 100 c.c. on the following two days. After an interval of four days they were tested with live virus type 'O'.

(b) Four hill bulls were infected with live virus Type 'O' intralingually. Twenty-four hours later they were treated with boiled skim milk administered intramuscularly, a course of three daily injections of 80 c.c., 100 c.c. and 100 c.c. being given to each animal.

(c) Two healthy hill bulls were kept as controls and they received virus only.

Results. (a) Two hill bulls reacted showing primary and secondary lesions. The remaining two did not react; they had probably become immune due to previous infection.

(b) All the four bulls reacted after the milk treatment showing primary lesions, three of them developed secondary lesions also.

(c) Typical reaction was observed in the controls. As a curative, milk therapy seems to have no effect. As a protective, its effect is none the better; besides, this method would hardly serve as a handy and practical one for disease control in the field. An earlier experimental trial in guinea-pigs proved that milk treatment is of no avail.

Marking nuts

Experimental treatment with marking nuts was undertaken at the suggestion of Lt. Col. M. S. Apte of Gwalior, who claimed to have had good results in the treatment and control of foot and mouth disease by the administration of marking nuts. He had also given details in regard to dose and mode of administration.

Experiment: (a) Three hill bulls were given one marking nut each daily for seven days from 21st February 1951 at the end of which they were tested with live virus type 'O'.

(b) Three hill bulls were given virus on 22nd January 1951 and were treated with marking nuts for five days from 23rd January 1951, each animal receiving in its feed two marking nuts daily.

(c) Three healthy hill bulls were kept as controls, receiving virus only.

Results. In the first lot, two hill bulls reacted and one did not show any reaction. In the second lot also two hill bulls reacted and one did not. Two of the controls reacted typically and one failed to show any lesion. In fact, in each lot one hill bull showed primary lesions, another primary and secondary lesions, and the third did not react probably having become immune due to previous infection. From the experiment it is evident that marking nuts have not proved of any avail both in the treatment and prophylaxis of the disease.

'Mokhur'

Experimental treatment of foot and mouth disease was carried out at the instance of the Indian Council of Agricultural Research, using *Mokhur*, a homeopathic drug supplied by Dr K. K. Lakhanpal of Delhi who had claimed great success with the drug and was giving a wide publicity to it amongst the members of the profession. He came personally to observe the experiment. He administered the drug orally in the dosage adequate for the guinea-pigs.

Experiment. Four lots of four guinea-pigs each were used; the first lot received *Mokhur*, followed 24 hours later by virus type 'O'; the second lot received virus and *Mokhur* practically simultaneously; the third lot was given virus first, followed 24 hours later by *Mokhur*; the fourth lot was kept as healthy controls receiving virus only.

Results. All the guinea-pigs of the four lots developed lesions practically in an identical manner. There was no difference in the type of reaction—primary lesions followed by generalisation—in all the tested animals. It was evident that *Mokhur* had neither preventive nor curative effect on foot and mouth disease. Details are given in Table II. In conclusion, it may be added in respect of *Mokhur* that a drug which has now been revealed by Dr Lakhanpal to be *Mokhur* was sent to this

Institute for trial of its efficacy by him through the Ministry of Agriculture, Government of India, in 1948. It was experimentally tried on hill bulls and guinea-pigs and the results showed that the drug possessed neither curative nor prophylactic value against foot and mouth disease infection [Seetharaman, 1949].

TABLE II

Details of treatment of foot and mouth disease with Mokhur

Serial No.	Guinea-pig No.	Weight in gm.	Date of giving Mokhur	Date of giving Virus Type 'O'	Reaction			Remarks
					22-9-51	23-9-51	24-9-51	
1	281	310	20-9-51	21-9-51	+0	++	++	
2	282	320	20-9-51	21-9-51	+0	++	++	
3	283	300	20-9-51	21-9-51	+0	++	++	Tongue epithelium peeling off
4	284	320	20-9-51	21-9-51	+0	++	++	
5	285*	320	21-9-51	21-9-51	+0	++	++	*Mokhur was again given on 23rd September 1951
6	286*	300	21-9-51	21-9-51	+0	++	++	do.
7	287	300	21-9-51	21-9-51	+0	++	++	
8	288	370	21-9-51	21-9-51	+0	++	++	Tongue epithelium peeling off
9	289	310	22-9-51	21-9-51	+0	++	++	
10	290	300	23-9-51	21-9-51	+0	++	++	
11	291	300	23-9-51	21-9-51	+0	++	++	Tongue epithelium peeling off
12	292	340	23-9-51	21-9-51	+0	++	++	
13	293	320	Virus controls not treated	21-9-51	+0	++	++	
14	294	380	do.	21-9-51	+0	++	++	
15	295	290	do.	21-9-51	+0	++	++	
16	296	290	do.	21-9-51	+0	++	++	

+0 = Primary lesions only
++ = Primary and generalised lesions

Experimental treatment was conducted using 'Wilco' foot and mouth disease cure, supplied by Dr Om P. Agrawal, Ayurvedacharya Homeopath, Hapur. It was on the same lines as the above experiment, using three guinea-pigs in each lot. The dose was three drops in water (10 drops dosage was recommended for cattle) and four such doses were given to guinea-pigs.

All the treated guinea-pigs reacted typically showing primary and secondary lesion as also the control animals. So this drug did not prove in any way better than the other previous ones. Details of the experiment are given in Table III.

TABLE III

Details of treatment of foot and mouth disease with 'Wilco'

Sl. No.	Guinea-pig No.	Weight in gm.	Date of giving medicine	Date of giving virus type 'O'	Reaction			
					29-9-51	30-9-51	1-10-51	2-10-51
1	323	450	27-9-51	28-9-51	+0	++	++	++
2	324	410	27-9-51	28-9-51	+0	++	++	++
3	325	340	27-9-51	28-9-51	+0	++	++	++
4	326	410	28-9-51	28-9-51	+0	+0	++	++
5	327	340	28-9-51	28-9-51	+0	++	++	++
6	328	340	28-9-51	28-9-51	+0	++	++	++
7	329	390	29-9-51	28-9-51	+0	++	++	++
8	330	370	29-9-51	28-9-51	+0	++	++	++
9	331	430	29-9-51	28-9-51	+0	++	++	++
10	332	330	Virus Controls not treated	28-9-51	+0	++	++	++
11	333	290	do.	28-9-51	+0	++	++	++
12	334	380	do.	28-9-51	+0	++	++	++

+0—Primary lesions only
++—Primary and generalised lesions

DISCUSSION

The results of these experiments clearly indicated that none of the drugs and other substances used had any curative effect, nor was there any indication in the tested animals that the severity of reaction was controlled or mitigated. Neither the onset of the disease was arrested nor was its course modified in any appreciable way.

It has been reported that chemo-therapeutic treatment has some beneficial effect in mitigating the course or severity of the disease [Stirling, *loc. cit.*]. However, it should be remembered that a comparatively large dose of the drug may affect the condition of the animal and thus make it unable to react to the infection with virus. Such an observation was made [Galloway, *loc. cit.*] in guinea-pigs treated with lugol's iodine. Though normal dosage did not prevent the development of primary and generalised lesions in guinea-pigs, yet when larger doses of iodine were given some animals did not develop lesions. This was attributed to the illness caused by large doses of iodine. In foot and mouth disease reaction, it is well-known that animals that are not in good condition fail to react.

Some of the drugs that were tested experimentally are reported to have been used by field workers in actual outbreaks. Conclusions in regard to the effect of the drugs are generally conflicting. It is, however, difficult to assess the value of a drug by large scale treatment of animals in various stages of the disease in an outbreak, unless carried out under controlled conditions.

The experiments carried out with the drugs and other substances as recorded in this article give clear and sufficient proof of the futility of therapeutic treatment for foot and mouth disease. Agents of drugs and patent medicines seem to advertise their products and bring them for sale in the open market without subjecting them to controlled experimental tests to ensure their efficacy. They even approach the Government, not to speak of professional workers, with a claim of efficacy for their products. It is, therefore, necessary for professional workers and the public to guard themselves against the indiscriminate use of such drugs against so highly an infectious disease as foot and mouth disease.

SUMMARY

Details are given of the experiments carried out to assess the therapeutic value of five drugs and substances, claimed to be effective against foot and mouth disease infection.

Against artificial infection with disease virus, none of them appears to have any beneficial effect, either as a curative or as a prophylactic.

Observations on the chemo-therapeutic treatment of other workers elsewhere are discussed.

ACKNOWLEDGMENT

The work has been carried out under a scheme of research financed by the Indian Council of Agricultural Research, New Delhi.

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INFLUENCE OF FACTORS AFFECTING SEX-DRIVE ON SEMEN PRODUCTION OF BUFFALOES—II

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(Received for Publication on February 15, 1955)

(With Plates VII-IX)

SOME of the major and essential factors governing the initial appearance, maintenance, disappearance and subsequent revival of male behaviour pattern are now clear from the numerous experiments carried out mostly on laboratory animals [Moore, 1938; Stone, 1939; Ball, 1939, 1940; Milovanov and Smirnov-Ugrjumov, 1940; Beach, 1940, 1942 (a), (b) and (c), 1944; Petersen *et al.*, 1941; Evlampieva, 1945; Smirnov-Ugrjumov, 1945; Beach and Holz, 1946 and Rasnussen, 1952]. Walton [1950] summarises the information on the structural pattern of male sex-behaviour as follows: (i) The male pattern is not sex-specific and is not dependent upon the possession of male organs, (ii) the pattern is innate and not learned, (iii) sex-response is elicited by the sum of the excitatory value of the sexual object and the sex-drive of the male, (iv) response is not 'all or nothing', but is graduated by varying completeness of expression and (v) performance of the sexual pattern may be facilitated or inhibited by the development of conditioned reflexes. Response is elicited by the sum of the sex-drive (increased by abstinence or decreased by use) and the algebraic addition of conditioned facilitation or inhibition.

The importance of more information on the sex behaviour of farm animals is being increasingly felt with the rapid adoption of the technique of artificial insemination as an accepted method of breeding. A few reports have appeared in which the earlier experiments of Milovanov and Smirnov-Ugrjumov [1940] on cattle were repeated [Hart, Mead and Regan, 1946; Sarthou-Mountegou, 1950; Hellstrom, 1947; Collins, Bratton and Henderson, 1951 and Branton, D'Arensborg and Johnston, 1952]. These papers cover but a fraction of the vast field remaining unexplored and only bring out the necessity of undertaking such experiments in cattle. With buffaloes, on the other hand, very little work on the subject had been undertaken so far. Buffaloes are of particular interest to India, for, compared to their relative size in population, they contribute a large proportion of the overall production of milk and milk products.

In an earlier paper [Prabhu and Bhattacharya, 1954] results of a detailed investigation on buffaloes where the effect of short term sex stimulus, in the form of providing an 'on heat' cow instead of the usual anoestrous dummy at the time of collection,



on the reaction time and semen characteristics were reported. It was found that the physiological condition of the dummy had no significant effect on sex-drive as judged by reaction time and quality of the semen obtained. Further, no 'carry over' effects due to frequent change in dummies which formed part of the experimental design employed could be detected. In the present study the effect of the following additional factors, introduced as before for a short period and then changed, were tried and their effect on sex-drive and semen quality determined.

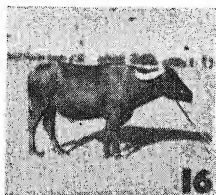
Factors investigated :

- (i) Male as teaser
- (ii) Different males as teasers
- (iii) Different coloured females as teasers
- (iv) Effect of five minutes cold shower bath prior to collection
- (v) Making collections in the evenings
- (vi) Making collections at night under artificial light

EXPERIMENTAL

The experiments were conducted on non-descript buffaloes purchased through the Institute contractors. At purchase, they possessed full mouths and appeared healthy and vigorous. A short term test which consisted in obtaining semen in an artificial vagina and typing it for quality was carried out on all animals presented for selection and only those which approached certain standards were selected. During the experimental period, the animals received rations consisting of wheat *bhoosa*, greens and concentrates. The last mentioned was made up of crushed oats and linseed cake in the proportion of 2 : 1 by weight. It was given at the rate of 3 lb. per 800 lb. body weight. The appearance and condition of bulls can be judged from the photographs on Plate VII. Bulls Nos. 40 and 26 which died are not included in the Plate. The experimental design employed was the same as used in our earlier study (*loc. cit.*) and consisted in changing over bulls between treatments following each collection. The horn number of bulls and their distribution in each of the six experiments are given below :

Experiment I (Male as teaser). Two series were run, one after the other. The first series was started on the 25th May 1953 and came to a close on the 6th June 1953. There were ten bulls. The group in which the first ejaculate was taken with male as teaser contained bulls Nos. 26, 28, 22, 20 and 25. The other group in which the first ejaculate was taken on the usual dummy consisted of bulls Nos. 40, 36, 16, 33 and 37. In the second series, the former group had bulls Nos. 16, 28, 31, 33 and 36 while the latter was made up of bulls Nos. 20, 22, 25, 37 and 40. The collections consisting of two ejaculates per collection were taken thrice a week. The number of teaser bull was 38.



1



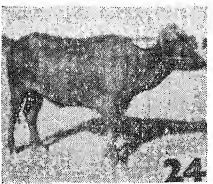
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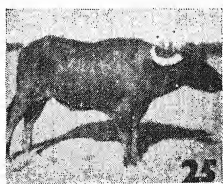
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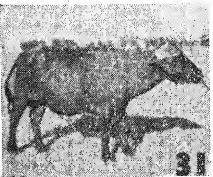
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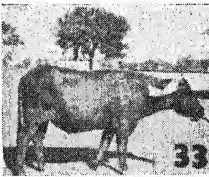
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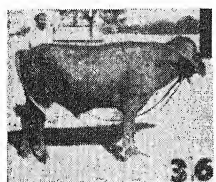
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11



12

PLATE I. Photographs of experimental buffalo bulls. The tatoo numbers of the bulls appear on the lower right hand corner.

Experiment II (different males as teasers). Only one series was run. It commenced on the 14th July 1953 and ended with a collection on the 25th July 1953. The teasers employed were bulls Nos. 31 and 40. There were only seven bulls in this experiment. The groups in which the first ejaculate was taken with bull No. 31 in the service crate had other bulls Nos. 37, 25 and 36 in it while the group wherein the other bull was used consisted of bulls Nos. 20, 22, 16 and 28. Collections were taken twice a week.

Experiment III (different coloured cows as teasers). Only a single series was run. It started on the 2nd March 1954 and came to a close on the 15th March 1954. There were 12 bulls in this experiment. One of the cows was dark and the other light in colour. Photographs of these two animals are given on Plate IX, Figs. (3) and (4). Bulls Nos. 23, 33, 28, 37, 24 and 22 had their first ejaculate taken on the light coloured female, while bulls Nos. 31, 20, 36, 38, 16 and 25 had theirs taken on the dark coloured females. Two collections per week were taken.

Experiment IV (shower bath prior to collection). One series was run. The experiment commenced on the 12th April 1954 and closed on the 22nd April 1954. There were 8 bulls. The teaser used was the one routinely used. The bulls in the group receiving the bath were Nos. 33, 22, 16 and 23. The other group was made up of bulls Nos. 37, 24, 28 and 25. Two collections per week were taken.

Experiment V (evening collection). This experiment was run side by side with experiment IV on the same lot of bulls. The morning collections commenced at 8-30 A.M., while the evening collections were taken at 3-30 P.M.

Experiment VI (night collection). Only one series formed the experiment. It was begun on the 25th March 1954 and came to a close on the 7th April 1954. Using the routine female teaser, collections were taken from 10 bulls divided into two groups. In the group in which the first ejaculate was taken during the day collection, were bulls Nos. 16, 24, 37, 23 and 38, while Nos. 25, 33, 28, 22 and 31 had the first ejaculate taken first during the night collection. Collections during the night were made with the aid of a Petromax lamp having 300 candle power. Two collections per week were taken.

It may be mentioned here that on the termination of each experiment, reassessment of bulls based on their latest performance of reaction time and semen quality was made and fresh groups formed at random for the subsequent experiment. That is why the same bulls were not carried in the same groups in all the experiments.

In addition to reaction time, the following semen criteria were studied in all the experiments: (i) Volume, (ii) initial motility, (iii) sperm concentration, (iv) percentage of abnormal spermatozoa, (v) total spermatozoa in ejaculate and (vi) initial pH.

RESULTS

The average values of reaction time and semen characteristics actually observed in the six experiments are presented in Table I. Summary of the analysis of variance appropriate to the 'Switch-back' design carried out is given in Table II. The figures mentioned are proportional quantities.

TABLE I

Average semen criteria and reaction time in the different experiments

Experiment No.	Factor studied	Ejaculate No.	Volume (c.c.)	Initial motility	Sperm concentration (M/c)	Percentage of abnormal sperm	Total sperm in ejaculate (M)	Initial p _H	Reaction time (seconds)
I	On male	I	1.6	1.1	617	10	898	6.9	32
		II	1.1	1.6	635	8	607	6.9	27
	On female	I	1.4	1.9	630	10	699	6.9	51
		II	1.3	0.8	782	9	998	7.4	53
I(a)	On male	I	1.5	1.3	531	10	672	6.9	30
		II	1.0	0.9	670	8	665	6.7	37
	On female	I	1.6	0.4	473	9	730	6.7	66
		II	1.2	1.0	672	8	700	6.9	31
II	On bull No. 31	I	1.4	1.9	633	9	1,012	6.9	42
		II	1.0	1.1	748	10	714	7.0	71
	On bull No. 40	I	1.5	1.9	746	10	956	6.9	49
		II	1.3	2.0	724	8	881	6.9	71
III	On light coloured female	I	2.1	2.1	916	19	2,265	6.9	37
		II	2.0	2.5	1,189	26	2,480	6.9	43
	On dark female	I	2.4	2.1	1,930	25	2,044	6.9	45
		II	2.0	2.4	1,204	21	2,132	6.9	45
IV	With bath	I	3.7	2.6	823	6	2,947	6.7	68
		II	3.2	2.6	989	6	2,581	6.7	90
	Without bath	I	3.8	2.3	600	5	2,074	6.7	53
		II	3.5	2.6	768	5	2,473	6.8	69
V	Morning	I	3.9	2.3	623	7	2,442	6.6	65
		II	3.4	2.7	783	6	2,316	6.8	75
	Evening	I	3.6	2.5	810	5	2,580	6.7	55
		II	3.2	2.6	974	5	2,738	6.7	75
VI	Day	I	3.7	2.3	520	22	2,048	6.8	59
		II	3.0	2.3	556	21	1,458	6.8	55
	Night	I	3.5	2.3	814	18	2,511	6.7	55
		II	2.5	2.5	806	13	1,632	6.8	55

TABLE II

Analysis of variance

Segal No.	Item studied	Eucalyptus No.	Variation	Experiment I(a)		Experiment I(b)		Experiment II		Experiment III		Experiment IV		Experiment V		Experiment VI	
				D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.
1	Volume	I	Treatment	1	8.65	1	0.33	1	5.66	1	7.23	1	72	1	0.98	1	1.08
			Error	8	65.64	8	0.16	5	12.73	10	24.13	6	3229	6	33.25	8	34.02
		II	Treatment	1	125.65	1	0.25	1	0.16	1	23.60	1	181	1	0.41	1	93.02
			Error	8	74.22	8	0.88	5	13.09	10	13.54	6	3521	6	35.45	8	32.40
2	Initial motility	I	Treatment	1	39.10	1	0.89	1	2.00	1	0	1	24.50*	1	3.13	1	0.99
			Error	8	64.37	8	27.73	5	41.00	10	4.04	6	2.48	6	0.04	8	2.88
		II	Treatment	1	23.10	1	1.99	1	23.47	1	3.00	1	0.12	1	3.12	1	19.35
			Error	8	61.80	8	3.78	5	55.82	10	3.59	6	1.56	6	1.06	8	9.22
3	Sperm concentration	I	Treatment	1	4175744	1	0	1	254.73	1	8801080	1	8652800	1	8820000	1	2037603*
			Error	8	11372868	8	91019	5	1288859	10	12442022	6	3340925	6	3512058	8	3305680
		II	Treatment	1	14624000	1	18865	1	32895	1	6885790	1	9740113	1	3057613	1	7921000
			Error	8	6233729	8	110925	5	1704913	10	9300559	6	8831029	6	9041679	8	2467120
4	Percentage of abnormal sperm	I	Treatment	1	2622464	1	0.01	1	6	1	4661*	1	145	1	1018	1	1689
			Error	8	17533407	8	9.20	5	40	10	681	6	437	6	292	8	2436
		II	Treatment	1	7430440	1	18.88*	1	72	1	5298	1	685	1	12	1	8237
			Error	8	3367743	8	2.35	5	242	10	1294	6	129	6	136	8	3530

* Significant at 5 per cent level

TABLE II—*contd.**Analysis of variance*

Serial No.	Item studied	Ex- periment No.	Variation	Experiment I (a)		Experiment I (b)		Experiment II		Experiment III		Experiment IV		Experiment V		Experiment VI	
				D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.	D.F.	M.S.
5	Total sperm in ejaculate	I	Treatment	1	39481690	1	442868	1	20274379	1	25010081	1	112385001	1	61228178	1	78237684
			Error	8	30590026	8	314630	5	6069575	10	98492492	6	72871798	6	81889612	8	26553003
		II	Treatment	1	907622	1	50375	1	5029664	1	224621880	1	6510050	2	45011072	1	2081184
			Error	8	14899365	8	308901	5	4630994	10	207200087	6	33695353	6	27092290	8	9135637
6	Initial pH	I	Treatment	1	0.58	1	0	1	2.40	1	0.18	1	72.00	1	0.18	1	0.08
			Error	8	0.96	8	0.92	5	0.14	10	0.26	6	72.00	6	0.80	8	0.44
		II	Treatment	1	0.72	1	0.01	1	0.15	1	0.56	1	64.24	1	0	1	0.37
			Error	8	1.70	8	0.61	5	0.15	10	1.06	6	36.00	6	0.45	8	0.59
7	Reaction time	I	Treatment	1	159613*	1	2384	1	1860	1	3107	1	41121	1	7813	1	22753
			Error	8	27771	8	3684	5	2894	10	18207	6	17637	6	23188	8	34165
		II	Treatment	1	254403*	1	409	1	31263	1	3888	1	113288	1	1463	1	16369
			Error	8	37662	8	1662	5	14713	10	15500	6	41068	6	59706	8	25600

* Significant at 5 per cent level

Experiment I

There was no marked change, as judged from the analysis, when a male was substituted for the routine teaser.

As for reaction time, however, statistically significant differences were observed in both ejaculates following the substitution of teaser. The over-all bulls' average reaction time with routine cow was 107 seconds and with male teaser 59 seconds.

In the second series, however, no such significant difference was noticed in reaction time. The respective over-all bulls' average reaction time with routine cow was 100 seconds and with the male teaser 67 seconds. Detailed examination of the bulls in the experiments showed that in the first series all the bulls recorded a higher reaction time (total of 1st and 2nd ejaculates) with the routine cow. In the second series, out of the 10 bulls, 7 bulls behaved as before, while the remaining 3 bulls, showed slightly higher values with male as a teaser.

As regards semen quality, the only departure from the results of the first series was the significant variation observed in respect of percentage of abnormal spermatozoa in the second ejaculate. The respective average values with routine cow and male teaser were 8.3 and 7.8 per cent.

Experiment II

No significant difference in respect of both reaction time and different criteria of semen was observed when two different males were used as teasers.

Experiment III

The colour of the cow in the service crate at collection also did not yield, in general, any significant influence on the reaction time and quality of semen. Only in respect of percentage of abnormal spermatozoa there was a significant variation between first ejaculate values with the two different coloured cows. The actual averages over bulls were 19.1 and 24.9 per cent respectively with light and black cows. The difference was significant at 5 per cent level. Incidentally, this experiment also indicated lack of marked effect with use of different females as teasers.

Experiment IV

The results obtained under this experiment showed that five minutes cold water shower bath administered to bulls prior to collection had no marked effect on reaction time and quality of semen—except on initial motility. A significant difference was observed in motility in the first ejaculate. The average for the first ejaculate with bulls given shower was 2.6 and without shower 2.3.

Experiment V

There was no significant difference in variation between collections made during the morning and the evening. The reaction time also showed no marked variation. This finding contradicts the belief of certain workers in the laboratory that morning collections are superior to evening collections.

Experiment VI

There was no significant change in the time taken when collections were made at night under the artificial light instead of during the day under sunlight. In semen quality, however, a significant difference in variation was observed in respect of sperm concentration of the first ejaculates. The average over bulls for day collections was 520 millions per c.c. as compared with 814 millions per c.c. of night collections.

Sex-drive and short term change in sex stimuli. Using the average over bulls and over experiments as an estimate of the intensity of sex-drive inherently present in the bulls of our experiments, the results obtained when different stimuli were applied, were re-arranged in the descending order of reaction time values and the figures are presented in Table III.

Out of the 14 bulls in the experiments, No. 23 had the highest average reaction time and bull No. 16, the lowest. It was noticed that while the latter jumped at once and gave a thrust, the former took time to explore the dummy and gave a thrust only after one or two attempts. A comparison of the reactions of these two extreme types to the new sexual stimuli would give an indication of their relative behaviours. If we take only the experiments involving the change of dummies and leave out of consideration the experiments like giving bath and changing the time of collection since they deal with effects other than sex ones, marked reaction could be observed in bull No. 23 to the change in sex stimuli and small or negligible in the case of bull No. 16. Similar also is the case with bull No. 40 which came near to bull No. 23 in sex-drive and bull Nos. 19 and 21 which had sex-drives nearer to bull No. 16. In the intervening cases the effects were rather not clear cut. If we divide all the bulls into two broad groups depending upon their level of sex drive, viz. those with sex-drive of 60 and less seconds and those having sex-drives above 60 seconds, then the first five bulls namely, Nos. 23, 40, 24, 26 and 25 fall in the latter category, while the remaining 9 bulls fall in the former. If now we consider their behaviour in experiments I (a) and (b), II and IV, we find that in the above 60 seconds group, out of 9 cases only in one case the results were different from the expected rest, while in one it was equal. In the below 60-seconds group, out of 30 cases there were 9 cases in which the results were different and two cases in which they were equal. This appears to suggest that bulls having higher reaction time are more susceptible to change in sex stimuli than bulls with lower reaction time.

Considering now the experiments in which cold shower bath was given prior to collection or collections taken during evening or at night and retaining again the two broad divisions in respect of sex-drive, we find that in the group with longer reaction time, out of 9 instances in two cases they behaved differently; while in the group with shorter reaction time, out of 17 cases in 7 cases the results were different from the others. This also shows that the bulls with reduced reaction time are less likely to notice any change than bulls with higher reaction times.

In addition to the results discussed already, certain peculiarities in the sex behaviour were exhibited by certain bulls which are briefly described below :

TABLE III
Sex-drive and reaction of bulls to different stimuli

Experiment No. Average overall	Stimuli tried R. T.	No. of bulls															
		23	40	24	26	25	22	37	33	29	28	36	31	38	10		
(a)	On male	145	128	116	76	63	53	43	38	34	24	21	19	15	14		
	On female																
	On male																
	On female																
(b)	On male		48		58	33	77	10	14	18	15	14			6		
	On female		134		92	36	79	12	65	58	29	16			11		
	On male		125			15	50	61	11	21	37	15	15		10		
	On female		228			41	48	21	55	36	26	18	16		11		
II	On 81					91	47	174		21	19	13			28		
	On 40					91	62	152		43	30	24			24		
	Shower	150		128		53	34	14	34		23				13		
	No shower	155		143		129	50	60	46		37				20		
IV	On light coloured cow	80		87		67	68	15	20	37	21	31	20	13	15		
	On black cow	165		61		75	24	15	27	32	21	37	26	16	11		
	Day	125		132		108	83	21	40		24		20	10	14		
	Night	176		140		56	32	16	52		26		21	14	13		
V	Morning	150		129		120	50	14	46		37				13		
	Evening	155		143		53	34	60	34		22				20		

The normal reaction of the buffalo bull trained for artificial service is to show sudden interest as it approaches the site of service as evidenced by hastened movement and low bellowing. On reaching the dummy, the outer labia are licked. If as a result of licking the dummy micturates as it normally does, the bull will sip the outflowing urine and open his lips exhibiting the teeth in a characteristic pose which is said to denote sexual excitement and pleasure. The exposure of the teeth are accompanied by a slight to and fro movement of the head. This is followed by a pause or the initial process may be repeated once or twice. It then gets ready to jump; the back is curved and with everted penis it will jump over the teaser and after exploring with the penis give a thrust where the penis finds the warm lubricated surface of the artificial vagina. It then falls back and regains the normal posture. The two characteristic poses of service are shown in Plate VIII, Figs. 1-4 for bulls No. 23 and 25.

In our studies we observed the following variations: bull No. 25 for example used to 'stroke' the artificial vagina before ejaculation. It was also in the habit of dancing, i.e. shifting the body weight in the mounted position alternately from one of the hind foot to the other—a practice attended with danger to the operator, who if not careful ran the imminent risk of his feet being crushed under the bull's hooves. This habit also annoyed the 'dummy' tied to the service crate which tried to wriggle out. Finally, after giving the thrust, the bull would try to rest for some time on the hind quarters of the teaser (Plate VIII, Fig. 5) and would reluctantly come down. A like tendency was noticed in bull No. 23 (Plate VIII, Fig. 6). Bull No. 16 was the quickest to react. It never wasted time in the preliminaries, but, on being led to the crate, immediately jumped and gave a thrust. The semen quality of this bull was uniformly good, though the volume was generally low.

The bull No. 22 preferred to ejaculate in the standing posture (Plate IX, Fig. 1). Similar behaviour pattern was also noticed in bull No. 37 (Plate IX, Fig. 2).

Bull No. 36 was a noted fighter. All other bulls avoided him. When he was tied in the crate as a teaser, the bulls refused service and showed a strong tendency to be away from him which was natural enough. When bull No. 36 was tried on one of the other bulls, at one stage instead of behaving normally he started 'buffing' the teaser and would have started attacking, if not timely controlled. No such tendency was shown by him when females were in the service crate.

DISCUSSION

Milovanov and Smirnov-Ugrjumov [1940] were the first to draw attention to the possibility of correcting semi-impotence and lethargy encountered in bulls by suitable change of sexual stimuli. They found that a bull accustomed to mate with black pied non-oestrous cow in an insemination shed, who refused service after some time showed sharp temporary increase in sexual activity on being transferred from the shed to the yard or when the non-oestrous cow was replaced by a cow on heat or when a differently coloured cow was provided. Application of worn wood to the non-oestrous cow with which it normally mated or the use of a dark pied non-oestrous cow from another farm produced similar results. Through



1



2



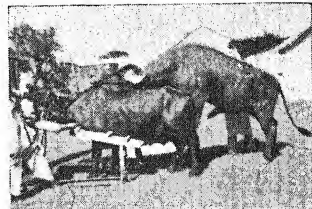
3



4



5



6

PLATE VIII. Photographs taken of some of the bulls at the time of collection

1. Bull No. 23 near the 'dummy'. Note the characteristic exhibition of teeth denoting sexual excitement

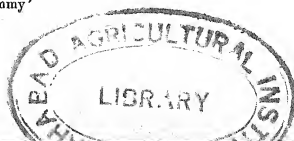
2. Bull No. 25 showing sexual excitement

3. Bull No. 23 giving the 'thrust' in the A. V.

4. Bull No. 25 giving the 'thrust' in the A. V. This bull was in the habit of stroking the A. V. and dancing

5. Bull No. 25 resting on the back of the 'dummy' after giving the 'thrust'

6. Bull No. 23 resting on the back of the 'dummy'





1



2



3



4

1. Bull No. 22 ejaculating in the A. V. in the standing posture
2. Bull No. 37 ejaculating in the A. V. in the standing posture
3. Photograph of the light coloured 'dummy' cow
4. Photograph of the dark coloured 'dummy' cow.



further tests, they were able to show that high sexual activity with oestrous cows was not due solely to the special odour of cows on heat, but appeared to be due to the constant change of cows that provided the novel and varied stimuli. In natural mating each cow by itself provides the novel and varied stimuli. But in artificial service, since collections are taken under uniform and unvaried sets of conditions, a factor of importance in the initial stages to train the bull to the technique through conditioned reflex, depending upon the length of service and the nature of the bulls, the reaction of the bulls is likely to get 'dulled'. It is then that the change of stimuli are best calculated to produce the desired results. Evalmpieva [1945] working on rabbits found direct correlation between the appearance of internal inhibition of sexual reflexes on the one hand and the monotony of the mating environment on the other. The more stereotyped and uniform were the conditions under which matings took place sooner the inhibition occurred. An increase of the interval between each mating to 48 hours as well as the alteration of environmental conditions slowed down the development of inhibition. The latter was evoked at an unequal rate in different males, failing to develop in some animals on account of variable type of nervous activity (temperament), peculiar to each animal. Smirnov-Ugrjumov [1945] classified temperamental types into four classes: (1) impetuous or uncontrollable, (2) lively, (3) quiet and balanced and (4) weak. Males of type (1) were not liable to develop inhibition due to external factors and were incapable of developing differential inhibition resulting in extinction of sexual reflexes, and did not show any signs of internal inhibition due to frequent matings in the same environment. Those of type (2), exhibited a transitory inhibition due to external factors, readily developed both positive and inhibitory sexual reflexes and quickly showed the symptoms of internal inhibition, if mated frequently in the same environment. The type (3) behaved mainly as type (2) but development of positive and inhibitory sexual reflexes occurred more slowly. Those of type (4) rapidly developed inhibition in sexual reflexes as a result of external and internal factors.

The buffalo bulls in our experiments belonged to types (2) and (3). Types (1) and (4) were absent. Since we had tried only the effect of short term changes of sexual stimuli and change of environment and given only one chance consisting of three 'tries' of five minutes duration, the effect of such changes could best be assessed through the reaction time values. In general, it was noticed that those with lower sex-drive responded better than those with higher sex-drive. These results bear out the findings of the Russian workers. But unlike the Russian workers, we had employed a delicate experimental design and analysis of the results showed significant variation only in the following: (i) reaction time when a bull was substituted for the routine anoestrous female in Experiment I(a), (ii) percentage of abnormal sperm in the second ejaculate of Experiment I(b), (iii) percentage of abnormal sperm in the first ejaculate of Experiment III, (iv) initial motility in first ejaculate of Experiment IV and (v) sperm concentration in the first ejaculate of Experiment VI. No significant variation could be detected in other cases.

The significant change in reaction time when the bull was substituted for the routine anoestrous cow was in all probability due to radical change in teasers. The negative results obtained when the experiment was repeated indicate that probably

the bulls had got used to the new change. The significant differences observed in respect of semen quality offer a problem on which further work alone can throw some light.

SUMMARY

1. Experiments were carried out with 14 buffalo-bulls to study the effect of (1) substituting a male for a female as teaser, (2) using different males as teasers, (3) using different coloured females as teasers, (4) giving 5 minutes cold water shower bath prior to collection, (5) making collections in the evenings and (6) making collections at night by artificial light, on the reaction time and quality of semen.

2. Only limited period consisting of 3 'tries' of 5 minutes duration was given for the trial. The treatments were changed following the 'switchback' design of experimentation.

3. Significant variation was obtained in respect of (i) 'reaction time' when a male was substituted for the routine female as teaser, (ii) 'percentage of abnormal sperm' in the second ejaculates of the second series of experiment with male as teaser, (iii) 'percentage of abnormal sperm' in the first ejaculates of the experiment with different coloured teasers, (iv) 'initial motility' in the first ejaculate of the experiment in which the bulls were subjected to a shower bath prior to collection and (v) 'sperm concentration' in the first ejaculate of the experiment in which collections were made at night. In the rest of the cases, and in items studied no significant differences could be detected.

4. It was observed that bulls with lower sex-drive showed greater reaction to change in the excitatory object or change in the time of collection than bulls with higher sex-drive. Estimates of sex-drive for this purpose was the over-all experiment.

5. Certain peculiar sex behaviour patterns of buffalo bulls are described.

ACKNOWLEDGMENTS

The author is thankful to Dr P. Bhattacharya, Head of the Division of Animal Genetics for his keen interest in this work and for encouragement. To the Director, Indian Veterinary Research Institute, Izatnagar, thanks are due for providing all facilities.

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LIMITED VERSUS *AD LIBITUM* FEEDING OF WHITE LEGHORN PULLETS

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(Received for publication on November 26, 1955)

IN most commercial egg producing areas the usual practice in feeding the birds is to feed either all or a part of the ration *ad libitum*. Approximately three-fourths of the feed consumed by a laying hen is used for body maintenance and only one-fourth for egg production [Vernon *et al.*, 1942]. The maintenance requirement will be satisfied before any feed is utilised for egg production [Halerow 1947]. Halerow [1947] reports that Montana flocks with the highest income were fed 90-100 lb. of feed per hen annually. This amount is more than 4 oz. per hen per day. Jull [1938] states that a Leghorn hen laying approximately 200 eggs annually should consume about 81 lb. of feed per year. This is about 3.5 oz. per day. Heuser [1946] reporting on work of Temperton and Dudley states that restrictions on feed of laying pullets resulted in lower egg production and lower final body weight as compared with pullets fed *ad libitum*. Romanoff and Homanoff [1949] report a positive correlation between body weight and total egg production of pullets.

In villages in India, generally eggs are produced without feeding the hens. The only feed which the hen receives is what she can pick up for herself around the village. The villager, therefore, assumes that the eggs he obtains from these hens is a profit. There are differences of opinion in India as to whether it is profitable to feed a laying flock for maximum production. One common practice in feeding the laying flock is to limit the amount of feed provided daily.

In an attempt to determine the effect of a limited feeding as compared to *ad libitum* feeding for egg production, it was considered desirable to compare the two systems of feeding in the case of two similar groups of pullets.

EXPERIMENTAL

Sixty-two White Leghorn pullets about six months of age raised on the Agricultural Institute Farm from day-old chicks were divided into two groups—those with even numbered wing bands into one group and those with odd numbered bands into the other. The groups were given by turn, *ad libitum* or limited feeding. They were assigned by turn one of the two pens of equal size and type. Two Leghorn

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cocks were placed in each pen. The following ingredients in the ratios indicated were ground together, thoroughly mixed and fed to both groups of layers.

Maize	36 per cent
Groundnut cake	22 per cent
Wheat bran	12 per cent
Gram	8 per cent
Wheat	12 per cent
Fish meal	5 per cent
Limestone	2 per cent
Mineral mixture	3 per cent
(50 per cent salt, 50 per cent steamed bonemeal, 0.05 per cent potassium iodide)	

Group A received this mixture *ad libitum* offered in a self-feeder. Group B received the same mixture at the rate of 3 oz. per hen per day fed in two parts, morning and evening. Fresh greens were fed daily to both groups in equal amounts. Clean fresh water was supplied to both groups. Body weight of each bird was determined and recorded at the beginning of the project on October 1 and each month thereafter throughout the six months of the test. Trap-nests were provided and the eggs produced daily were recorded for individual hens. The eggs produced on the first and third Wednesday of each month were weighed and the average weight of eggs for these two days was considered the average for that month. The experimental period, October to March, is the cooler part of the year in Allahabad, the maximum air temperature being about 90°F and minimum about 40°F.

At the end of November after a two-month period the feeding systems were reversed. The Group A was put on limited feeding and Group B on *ad libitum*. At the end of January the systems were reversed again to the original procedure with Group A on *ad libitum* and Group B on limited feeding which continued up to April 1. Under this procedure Group A was fed *ad libitum* through October and November, limited feeding during December and January and *ad libitum* again during February and March. Group B was on limited feeding during October and November, on *ad libitum* during December and January and on limited feeding through February and March.

RESULTS AND DISCUSSION

There was wide variation in the number of eggs produced by individual hens (Table I). With the exception of Group B during Period I, there was a direct relationship between the total production by periods and the system of feeding. Statistical analysis of the data shows a highly significant difference in egg production in favour of *ad libitum* feeding [Snedecor, 1946, page 422], (Appendix Table I). *Ad libitum* feeding resulted in greater egg production to the extent of 3.60 eggs per two-month period, with standard error of 1.02 eggs. Data on egg production and feed consumption are summarized in Table II.

TABLE I

Egg production per hen in two-month feeding periods from October 1 to March 31

Group A			Group B		
Period I (ad lib.)	Period II (limited)	Period III (ad lib.)	Period I (limited)	Period II (ad lib.)	Period III (limited)
36	11	5	19	20	14
43	8	39	43	38	31
28	13	33	41	41	35
42	42	42	43	35	30
43	28	30	14	10	18
19	13	36	26	23	22
26	25	26	21	24	28
27	27	34	28	25	32
16	11	21	34	32	10
21	16	37	31	30	18
44	41	31	36	42	27
51	43	38	33	43	20
41	40	35	38	37	27
43	45	28	21	10	23
7	23	28	41	35	36
33	31	25	33	22	38
20	28	30	35	30	23
34	39	44	33	36	24
38	27	25	33	33	27
17	29	35	31	23	24
42	32	43	18	18	14
5	9	17	46	36	29
36	37	38	35	27	35
8	17	32	41	32	21

TABLE I—*contd.**Egg production per hen in two-month feeding periods from October 1 to March 31*

Group A			Group B		
Period I (<i>ad lib.</i>)	Period II (limited)	Period III (<i>ad lib.</i>)	Period I (limited)	Period II (<i>ad lib.</i>)	Period III (limited)
41	14	28	29	39	33
22	16	17	45	47	39
16	33	42	32	30	34
41	8	26	42	38	28
38	32	32	41	38	32
17	14	39	23	42	35
22	12	30	21	31	25
917	765	966	1009	976	860
TOTAL: 2648			TOTAL: 2845		

TABLE II

Total egg production by periods, total feed consumed and feed consumed per dozen eggs produced by White Leghorn hens under different systems of feeding

Period	Group A				Group B			
	Egg system	Total feed (lb.)	Daily feed per hen (oz.)	Feed per doz. eggs (lb.)	Egg system	Total feed (lb.)	Daily feed per hen (oz.)	Feed per doz. eggs (lb.)
Oct.-Nov.	917 <i>Ad lib.</i>	422	3-44	5-6	1009 Limited	378-2	3-0	4-5
Dec.-Jan.	765 Limited	334-4	3-0	6-0	976 <i>Ad lib.</i>	525-0	4-05	6-4
Feb.-March	966 <i>Ad lib.</i>	451-5	3-7	5-6	860 Limited	365-8	3-0	5-1

The hens in Group A showed a very definite reaction in production to the system of feeding. The amount of feed consumed per dozen eggs produced was 5-6 lb. in each period with *ad libitum* feeding and 6-0 lb. on limited feeding. This is the expected pattern of efficiency; as the maintenance requirement for a low producer is the same as for a high producer of the same size; so any reduction in feed would tend to reduce egg production since body requirements will be met first. The hens in Group B consumed only 4-5 lb. of feed per dozen eggs produced during Period I and 5-1 lb. per dozen during Period III under limited feeding. They consumed 6-4 lb. feed per dozen eggs produced during Period II under *ad libitum* feeding. The amount of feed consumed by Group B during Period II seems excessive when compared to feed consumption of Group A under *ad libitum* feeding, yet it is only slightly more than 4 oz. per hen per day, which is generally accepted as the usual amount required. A portion of this extra feed consumed was used in producing increased body weight as the average body weight of this group increased by 0-35 lb. per hen during this period (Table III).

The hens in Group A on *ad libitum* feeding gained 0.52 lb. per hen during Period I while those in Group B on limited feeding during this period gained only 0.39 lb. per hen. During Period II when Group A was on limited feeding the birds gained at an average 0.23 lb. per hen while those in Group B on *ad libitum* feeding gained 0.35 lb. per hen during the same period. During the third feeding period the average weight per hen decreased in each group. The average weight per hen decreased by 0.62 lb. in Group A and 0.86 lb. in Group B respectively during the third feeding period, on *ad libitum* and limited feeding. Although the average body weight decreased more than half a pound, the hens in Group A produced more eggs during this period than during any other period of the experiment. The hens in Group B decreased by more than three-fourths of a pound per hen in body weight during Period III and produced the smallest number of eggs of any period during the experiment. The weights of individual hens at the beginning and end of each feeding period are shown in Table III.

When changes in body weight of individual hens are calculated for the different feeding periods and analysed in the same manner as for egg production, there is a significant difference in body weight changes in favour of *ad libitum* feeding. However, disagreement with regard to A and B would also arise if the natural trend of weight is substantially curved, as the data suggest. The data show a gain in body weight during the first two two-month periods followed by a loss in the third period and even though the changes appear to be influenced by feeding there is some doubt as to the true nature of the treatment effect.

TABLE III

Body weight (in lb.) of individual hens at the beginning and end of different feeding periods

Group A				Group B			
Period I (<i>ad lib.</i>)	Period II (limited)	Period III (<i>ad lib.</i>)		Period I (limited)	Period II (<i>ad lib.</i>)		Period III (limited)
Oct. 1	Nov. 30	Jan. 31	March 31	Oct. 1	Nov. 30	Jan. 31	March 31
2.8	3.1	3.4	3.4	3.2	3.8	3.7	3.4
3.1	3.3	4.5	3.0	3.4	3.9	3.7	3.5
3.1	3.3	3.9	3.1	3.4	3.8	3.6	3.5
3.5	4.0	3.8	3.4	4.2	4.4	5.2	4.1
3.1	3.6	4.0	3.4	3.6	4.1	5.0	3.6
3.3	3.9	4.5	3.7	3.6	4.1	4.5	3.5
3.4	3.9	4.2	3.3	3.5	3.9	3.9	3.3
3.1	3.8	3.5	3.4	4.2	4.9	5.1	4.3

TABLE III—*contd.*

Body weight (in lb.) of individual hens at the beginning and end of different feeding periods

Group A				Group B			
Period I (<i>ad lib.</i>)	Period II (limited)	Period III (<i>ad lib.</i>)		Period I (limited)	Period II (<i>ad lib.</i>)	Period III (limited)	
Oct. 1	Nov. 30	Jan. 31	March 31	Oct. 1	Nov. 30	Jan. 31	March 31
2.9	3.2	3.6	2.7	3.8	4.3	4.5	3.6
3.4	3.6	4.1	3.6	3.8	3.9	4.1	3.4
3.2	3.9	3.9	3.6	3.8	4.3	4.9	3.6
2.9	3.5	3.5	2.9	3.3	3.8	4.4	3.1
3.3	3.9	3.8	4.0	4.1	4.4	4.5	3.9
3.1	3.4	3.3	3.1	3.6	3.8	4.5	3.6
2.8	3.6	3.6	3.3	3.2	3.5	4.2	3.0
2.6	3.6	3.4	3.0	3.5	3.8	4.0	3.1
3.5	3.7	4.4	3.3	3.0	3.4	3.9	3.0
3.6	5.0	4.9	3.9	3.1	3.6	3.8	3.0
2.8	3.0	3.4	2.8	3.2	3.6	4.0	3.4
3.9	4.7	4.7	3.5	3.1	3.2	3.9	2.9
3.3	3.0	4.2	3.1	2.7	3.1	3.2	2.4
3.3	3.6	4.4	3.3	3.0	3.1	3.7	2.7
3.4	3.9	4.4	3.5	4.1	4.3	5.0	4.2
3.3	3.7	4.2	3.2	3.0	3.2	3.4	2.9
3.3	3.9	4.2	3.4	3.1	3.7	4.0	3.1
2.8	3.2	3.5	3.0	3.3	3.6	3.9	3.2
3.5	4.8	4.4	3.6	3.1	3.5	3.7	2.9
3.6	3.8	3.9	3.7	3.5	4.0	4.2	3.0
2.8	3.0	3.3	3.0	3.0	3.2	3.3	2.6
3.3	3.6	3.8	3.2	3.3	3.6	3.7	3.1
2.4	2.8	2.8	2.8	4.1	4.9	5.0	4.3
Average	3.17	3.69	3.92	3.44	3.83	4.18	3.32

There was no evidence in this experiment indicating any correlation between body weight at the beginning of the test and total eggs produced nor between body weight and eggs produced during the first month of the test.

TABLE IV

Average weight of individual egg (by months) produced by White Leghorn hens over a six-month period

Group	October	November	December	January	February	March
	(Ounces per egg)					
Group A	2.02	1.97	2.04	2.04	2.13	1.95
Group B	2.17	1.98	2.06	2.14	2.11	1.92

There was no apparent difference in egg size attributable to the system of feeding. Group B on limited feeding produced eggs slightly larger than those of Group A on *ad libitum* feeding during October and November. Egg size was maintained by Group A during December and January while on limited feeding. Eggs produced by Group A during February and March while on *ad libitum* feeding were slightly larger than those produced by Group B on limited feeding during the same period. Egg size of both the groups was smallest during March.

SUMMARY

Two groups of 31 hens each were used in a double reversal feeding trial for comparing *ad libitum* and limited feeding for egg production. The difference in egg production under the two systems of feeding was highly significant in favour of *ad libitum* feeding. *Ad libitum* feeding resulted in greater egg production to the extent of 3-60 eggs per two-month period, with standard error of 1-02 eggs.

The Group-A hens produced eggs more efficiently on *ad libitum* feeding while Group-B hens produced eggs more efficiently on limited feeding.

There is some indication that *ad libitum* feeding had a significant influence upon body weight but due to the curved trend in weight data there is some doubt as to the true nature of treatment upon the body weight.

There was no correlation between initial body weight and first month's egg production nor between initial body weight and total egg production.

There was no significant relationship between egg size and system of feeding in this experiment.

ACKNOWLEDGMENT

The authors express their appreciation to Mr H. W. Norton, Professor of Agricultural Statistics, University of Illinois, U. S. A. for his kindness in checking the statistical analysis of the results of this experiment.

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APPENDIX I

Eggs produced by individual hens by two-month periods

Group A				Group B			
P ₁ (ad lib.)	P ₂ (limited)	P ₃ (ad lib.)	P ₁ -2P ₂ +P ₃	P ₁ (limited)	P ₂ (ad lib.)	P ₃ (limited)	P ₁ -2P ₂ +P ₃
36	11	5	36-22+5=19	19	20	14	19-40+14=-7
43	8	39	43-16+39=66	43	38	31	43-76+31=-2
28	13	33	28-26+33=35	41	41	35	41-82+35=-6
42	42	42	42-84+42=0	43	35	39	43-70+39=12
43	28	30	43-56+30=17	14	10	18	14-20+18=12
19	13	36	19-26+36=29	26	23	22	26-46+22=-2
26	25	26	26-50+26=2	21	24	28	21-48+28=-1
27	27	34	27-54+34=7	28	25	32	28-50+32=-10
16	11	21	16-22+21=15	34	32	19	34-64+19=-11
21	16	37	21-32+37=26	31	30	18	31-60+18=-11
44	41	31	44-82+31=-7	36	42	37	36-84+31=-11
51	43	38	51-86+38=-3	33	43	20	33-86+20=-33
41	40	35	41-80+36=-4	38	37	27	38-74+27=-9
43	45	28	43-90+28=-19	21	19	23	21-38+23=-6
7	23	28	7-46+28=-11	41	35	36	41-70+36=-7
33	31	25	33-62+25=-4	35	22	38	35-44+38=-20

APPENDIX I—*contd.**Eggs produced by individual hens by two-month period*

Group A				Group B			
P_1 ad lib.	P_2 limited	P_3 ad lib.	$P_1-3P_2+P_3$	P_1 limited	P_2 ad lib.	P_3 limited	$P_1-2P_2+P_3$
20	28	30	$20-56+30=-6$	35	30	23	$35-60+23=-2$
34	39	44	$34-78+41=0$	33	36	24	$33-72+24=-15$
38	27	25	$38-54+25=9$	33	33	27	$33-66+27=-6$
17	20	35	$31-58+35=-6$	31	23	24	$31-46+24=9$
42	32	43	$42-64+43=21$	18	18	14	$18-36+14=-4$
5	9	17	$5-18+17=4$	46	36	29	$46-72+29=3$
36	37	38	$36-74+38=0$	35	27	35	$35-54+35=16$
8	17	32	$8-34+32=6$	41	32	21	$41-64+21=-2$
41	14	28	$41-28+28=41$	29	39	33	$29-78+33=-16$
22	16	17	$22-32+17=7$	45	47	39	$45-94+39=-10$
16	33	42	$16-66+42=-8$	32	30	34	$32-60+34=-6$
41	8	26	$41-16+26=51$	42	38	28	$42-76+28=-6$
38	33	32	$38-66+32=4$	41	38	32	$41-76+32=-3$
17	14	39	$17-28+39=28$	23	42	35	$23-84+35=-26$
22	12	30	$22-24+30=28$	21	31	25	$21-62+25=-16$
917	765	966	353	1,009	976	860	-83

$$\text{Group A} - 19^2 + 66^2 + 35^2 \text{---etc.} + 29^2 = 15,223 \quad \frac{(353)^2}{31} = 11,203.4$$

$$\text{Group B} - (-7)^2 + (-2)^2 + (-6)^2 \text{---etc.} + (-16)^2 = 4,941 \quad \frac{(-83)^2}{31} = 4,718.8$$

$$\frac{11,203.4 + 4,718.8 = 15,922.2}{\frac{[353 - (-83)]^2}{62} = 3,066.06} \quad \frac{15,922.2}{60} = 265.37$$

$$\frac{3,066.06}{265.37} = 11.55$$

$P < 0.01$ by
Behrens-Fisher Test

APPENDIX II

Net changes in body weight of individual hens during each two-month feeding period

Group A (lb.)				Group B (lb.)			
P_1 ad lib.	P_2 limited	P_3 ad lib.	$P_1-2P_2+P_3$	P_1 limited	P_2 ad lib.		P_3 limited $P_1-2P_2+P_3$
0.3	0.3	0	$0.3-0.6+0=0.3$	0.6	-0.1	-0.7	$0.6-(-0.2)+(-0.7)$ = 0.1
0.2	1.2	-1.5	$0.2-2.4+(1.5)$ = -0.7	0.5	1.0	-1.4	$0.5-2+(-1.4)$ = -0.9
0.2	0.6	-0.8	= -1.8	0.4	-0.2	-0.3	= -0.5
0.5	-0.2	-0.4	= -0.5	0.2	0.8	-1.1	= -0.5
0.5	0.4	-0.6	= -0.9	0.5	0.9	-1.4	= -0.7
0.6	0.6	-0.3	= -1.4	0.5	0.4	-1.0	= -1.3
0.5	0.3	-0.9	= -1.0	0.4	0	-0.6	= -0.2
0.7	-0.3	-0.1	= 1.2	0.7	0.4	-0.8	= -0.9
0.3	0.4	-0.9	= -1.4	0.5	0.2	-0.9	= -0.8
0.2	0.5	-0.5	= -1.3	0.1	0.2	-0.7	= -1.0
0.7	0	-0.3	= -0.3	0.4	0.6	-1.4	= -0.7
0.6	0	-0.6	= -0.6	0.5	0.6	-0.7	= -0.5
0.6	-0.1	-0.2	= -0.6	0.3	0.1	-0.6	= -0.5
0.3	-0.1	-0.2	= -0.3	0.2	0.7	-0.9	= -1.0
0.8	0	-0.3	= -0.3	0.5	0.3	-0.7	= -0.8
1.0	-0.2	-0.4	= 1.0	0.3	0.2	-0.9	= -1.0
0.2	0.7	-1.1	= -2.3	0.4	0.5	-0.9	= -1.5
0.4	-0.1	-1.0	= -0.4	0.5	0.2	-0.8	= -0.7
0.2	0.4	-0.6	= -1.2	0.4	0.4	-0.6	= -1.0
0.8	0	-1.2	= -0.4	0.1	0.7	-1.0	= -2.3
0.7	0.2	-0.9	= -0.6	0.4	0.1	-0.8	= -0.6
0.3	0.8	-1.1	= -2.4	0.1	0.6	-1.0	= -2.1
0.5	0.5	-0.9	= -1.4	0.2	0.7	-0.8	= -2.0
0.4	0.5	-1.0	= -1.6	0.2	0.2	-0.5	= -0.7
0.6	0.3	-0.8	= -0.8	0.6	0.3	-0.9	= -1.0
0.4	0.3	-0.5	= -0.7	0.3	0.3	-0.7	= -1.0
1.3	-0.4	-0.8	= 1.3	0.4	0.2	-0.8	= -0.8
0.2	0.1	-0.2	= -0.2	0.5	0.2	-0.8	= -0.7
0.2	0.3	-0.3	= -0.7	0.2	0.1	-0.7	= -0.7
0.3	0.2	-0.6	= -0.7	0.3	0.1	-0.6	= -0.5
0.4	0	0	= 0.4	0.8	0.1	-0.7	= -0.1
14.0	7.2	-19.5	-19.0	11.9	11.2	-25.8	-36.3

$$\text{Group A} = (-3.7)^2 + (-1.8)^2 + 0.1^2 + 0.4^2 + 49.68 - \frac{(-19.0)^2}{31} = 38.04$$

$$\text{Group B} = 0.1^2 + (-2.9)^2 + 0.5^2 + (-2.5)^2 + \dots + (-0.1)^2 = 64.01 - \frac{(-36.3)^2}{31} = 21.51$$

$$38.04 + 21.51 = 59.55$$

$$\frac{59.55}{60} = 0.9925$$

$$\frac{[-19 - (36.3)]^2}{62} = 4.8263$$

$$\frac{4.8273}{0.9925} = 4.863$$

$$P < 0.05$$

MEDULLATION IN WOOL—V

TREATMENT OF MEDULLATED WOOL WITH WOOL PROTEIN EXTRACTS

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(Received for publication on April 11, 1955)

FOLLOWING the successful synthesis of polypeptides from the anhydrides of N. carboxy- α -amino acids by Woodward and Sehranin [1947], many attempts have been made to copolymerize the anhydrides of different aminoacids by Leggett Bailey [1950]. The structures of these polymerized products have been extensively studied using X-ray diffraction and other methods by Astbury, *et al.* [1948] and Bamford, *et al.* [1949]. The deposition of these anhydrides especially the anhydrocarboxyglycine on the wool fibres to make wool unshrinkable has also been described by Baldwin, Barr and Speakman [1946].

The possibility of producing regenerated protein fibres has also been investigated. The proteins for such fibres is obtained by dissolving some polypeptides in aqueous sodium sulphide and precipitating by an acid. The product after mixing with lactic casein is dispersed in alkali and extruded in a suitable salt or acid bath. The preliminary attempts were not very successful and the possibility of choosing the proper extrusion technique and suitable hardening after-treatment has been investigated extensively by Wormell [1948].

In a later paper by Wormell [1950], the author has indicated specially the methods of producing regenerated keratin fibre from wool. In this method the wool degradation product from sodium sulphide is refined in cuprammonium solution and is spun into a yarn either from cuprammonium or ammonium bath. The authors have given the optimum conditions of extrusion, prehardening and subsequent hardening and stretching. The structure of such a regenerated fibre has shown that it consists essentially of β -keratin form. The possibility of obtaining the α -keratin form for the regenerated proteins has been indicated by Mercer [1949]. It is shown that by dissolving even a hard keratin in strong solvent like saturated urea containing reducing agents, two kinds of precipitated proteins could be prepared, one at pH 6-7 at 40°C and the other at pH 8-9 at 50°C. The second material specially gives fine fibres with the characteristics of α -keratin.

In the light of these experiments it was thought interesting to investigate the possibility of impregnation and subsequent combination of the polypeptide in the hairy portion of the medullary space of coarse wool. In general there are three types of treatments that can be considered with a view to modify the nature of hairy wool by filling up the hollow central canal in the medullary portion. Firstly, the polymer treatment has to be considered. Such a treatment is used mainly to control the shrinking property of wool and it is generally known that it gives a surface deposition. The treatment of methyl-methacrylate monomer showed that it increases the diameter to about 200 per cent and makes the fibres hard and brittle.

Secondly the polypeptide synthesis from anhydrocarboxy acids has to be considered inside the fibre. The possibility of such synthesis inside the fibres has not been tried so far though it sounds promising. It is proposed to be undertaken. The last choice is on the lines of the present work where the techniques of regeneration of keratin fibres is tried to fill up the medullary hollow space in coarse wool. Such an investigation is very useful specially for the hairy coarse Indian wool, since if the hairy portions could be filled by appropriate polypeptides, the physical properties of the fibres would change to make it suitable for more useful purpose than merely as carpet wool. The methods tried during the present work were almost similar to those used for the synthetic polypeptide fibres but suitably modified to suit the present problem. Proteins were extracted by aqueous solutions of sodium sulphide and also of urea and precipitated by hydrochloric acid. The precipitated proteins were dissolved in alkali either alone or after blending with casein. A coarse hairy sample of wool with degree of medullation (hairiness) was treated with a solution similar to the one used in the spinning bath and was subsequently treated with solution of proteins and finally given the hardening treatment.

EXPERIMENTAL

The diameter of the sample was measured by microprojection by taking over 200 readings and mean-diameter and coefficient of variation calculated by the usual statistical methods. The percentage of medullation is described as the percentage of the length of hairy portion in the fibre to the total length and is measured by microprojections as discussed in part II of the present series.

Extraction of proteins from wool

Seventy grams of wool was dispersed in 2 litres of 25 per cent sodium sulphide under inert atmosphere of argon for 48 hours and undissolved portion was filtered off through a metal gauze. The dissolved protein was precipitated by bringing the clarified extract to pH 4 by the addition of hydrochloric acid. The precipitate was washed and dried. It was found that when extraction was done in air the yield was very poor and the mass became rather pulpy but under inert atmosphere the yield was over 60 per cent and the extraction neat. The precipitated protein was used to prepare two solutions for treatment.

Solution I. Five grams of protein was mixed with 15 gm. of lactic casein in 75 cc. of distilled water and kept stirring for one hour. 5 cc. of 20 per cent caustic soda was added and the concentration of free caustic soda in the solution adjusted to 0.5 per cent.

Solution II. Fifteen grams of protein was soaked in 50 cc. of distilled water for one hour. Cuprammonium solution was prepared and precipitated according to the method of Happey and Worwell. The precipitate was dissolved in concentrated ammonia and finally adjusted to pH 8.

Solution III. Five grams of wool was dissolved in saturated aqueous urea at room temperature and the undissolved portion filtered off. The protein solution was diluted to 400 cc.

Preparation of wool samples

The samples were carefully scoured, first with 0.1 per cent neutral soap solution at about 70°C and then degreased by soxhlet extraction with benzene (20 times).

It was finally washed in distilled water and dried. The samples before being treated with different protein solutions were pre-treated with solutions of the type usually suggested for spinning bath.

For Solution I, a weighed quantity of the sample of wool was pre-treated with solution containing 5 per cent sulphuric acid, 10 per cent sodium sulphate, and 30 per cent hydrated magnesium sulphate. Two batches of four lots of 2.5 g. each of wool were treated in this solution for two hours and eight hours each. Two samples from each of these batches were taken and washed in distilled water at room temperature and dried while the remaining two samples from each of the two batches were dried at room temperature without washing. One washed and one unwashed sample from each of the two batches with two hours and eight hours treatment were treated with solution I for one hour and four hours respectively. All these eight samples were treated with a hardening bath containing 10 per cent sodium sulphate and 1 per cent formaldehyde and washed with distilled water, dried and taken for examination. The diameter, C.V. and medullation are given in Table I.

TABLE I
Effect of 'Solution P' treatment on medullated wool.

Serial No.	Pre-treatment 5 per cent H_2SO_4 , 10 per cent Sod. sulphate and 30 per cent hydrated magnesium sulphate	Other treatments	Solution I treatment	Mean Diameter in μ	C. V. in percentage	Medulla- tion in percent- age
Original	..	..	..	43	46	22
1	2 hours	Washed and dried	One hour	47	35	24
2	2 hours	Washed and dried	Four hours	45	39	22
3	2 hours	Unwashed and dried	One hour	47	45	24
4	2 hours	Unwashed and dried	Four hours	45	43	23
Original	..	..	..	43	56	32
5	8 hours	Washed and dried	One hour	37	51	28
6	8 hours	Washed and dried	Four hours	40	49	30
7	8 hours	Unwashed and dried	One hour	42	46	22
8	8 hours	Unwashed and dried	Four hours	38	45	24

For solution II treatment similar pre-treatment was given to another batch of eight samples and treated with protein solution II as in the previous case. The same hardening bath was used. The results of the treatment are given in Table II.

TABLE II

Effect of 'Solution I' treatment on medullated wool.

Serial No.	Pre-treatment 5 per cent H_2SO_4 10 per cent Sod. sulphate and 30 per cent Hydrated Magnesium sulphate	Other treatments	Solution I treatment	Mean Diameter in μ	C. V. in percentage	Medulla- tion in percent- age
Original	..	..	..	42	39	30
1	2 hours	Washed and dried	One hour	42	46	26
2	2 hours	Washed and dried	Four hours	40	41	18
3	2 hours	Unwashed and dried	One hour	39	43	19
4	2 hours	Unwashed and dried	Four hours	43	49	14
Original	..	..	..	68	55	48
5	8 hours	Washed and dried	One hour	60	50	46
6	8 hours	Washed and dried	Four hours	54	55	48
7	8 hours	Unwashed and dried	One hour	58	52	48
8	8 hours	Unwashed and dried	Four hours	60	59	46

For solution III treatment, four weighed lots of wool samples were soaked in distilled water at 60°C for eight hours and were put in oven at 70°C. The lots were successively removed from oven after one hour, 2½ hours, 4 hours and 6 hours, and then treated with 100 cc. of solution III for 1½ hours. The samples were washed and dried. The results are given in Table III.

TABLE III
Effect of Solution III treatment on medullated wool.

Serial No.	Treatment with distilled water at 60°C	Period of drying in oven at 70°C	Solution III treatment	Mean diameter in μ	C. V. in percentage	Medullation in percentage
Original	..	..	..	64	66	49
1	8 hours	One hour	1½ hours	59	65	42
2	8 hours	2½ hours	1½ hours	46	67	34
3	8 hours	Four hours	1½ hours	51	65	37
4	8 hours	Six hours	1½ hours	50	57	38

DISCUSSION

The results show that two hours pre-treatment followed by Solution I treatment for one or four hours does not change the properties of the fibres. The fibres show a decrease in medullation with eight hours pre-treatment followed by Solution I treatment on unwashed samples for one hour and four hours. The medullation falls from 32 to about 23 per cent. Since the mean diameter does not change, it shows that the protein has penetrated inside the fibres. It is clear that washing the sample after pre-treatment does make a difference. In the case of Solution II, Table II shows that two hours pre-treatment followed by one or four hours treatment with solution II reduces the medullation considerably. In the case of sample 4 it falls to 14 from 30 per cent. The reduction of medullation in four hours treatment in washed sample is about the same as one hour in unwashed sample. Curiously enough Solution II does not change the characteristics of wool after eight hours pre-treatment. In the case of Solution III the characteristic improves as the drying time is increased successively up to two and a half hours after soaking for eight hours in water. It, however, does not show further improvement on drying after increasing the drying time before Solution III treatment.

The results show the expected change in the characteristics of the fibres. The fibres maintain their other characteristics of 'feel', 'tensile strength' which were shown by the preliminary experiments. As to whether such a modification in fibre characteristics increases the spinning value of the fibres or not has yet to be seen. It is very likely that the treatment with N-carboxy α -amino anhydride may give more promising results.

ACKNOWLEDGMENT

The authors are grateful to the Indian Council of Agricultural Research for financial help for this scheme and also for financial help to one of them (T.K.D.) and for giving them permission to publish these results.

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SOME OBSERVATIONS ON THE MORPHOLOGY AND PATHOGENICITY OF *MONIEZIA EXPANSA* (Rudolphi, 1810)

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(Received for publication on August 10, 1955)

(with two Text-Figures)

THREE species of the anoplocephaline genus *Moniezia*, *M. expansa* [Rudolphi, 1810], *M. benedeni* [Moniez, 1879] and *M. denticulata* [Rudolphi, 1810], have proved to be of veterinary interest. These species are mainly based on the presence or absence of and the character of the interproglottidal glands, which are sacular in *M. expansa*, linear in *M. benedeni* and totally absent in *M. denticulata*. Bhalerao [1935] records the occurrence of all these three species in certain localities of India. *M. expansa* appears to be by far the commonest and most widespread species in the world and in India too. The morphology of this parasite has been fairly well studied by a number of helminthologists in different countries. The object of this article is to record some interesting observations of diagnostic value and to stress the importance of this worm as a significant etiological agent in causing mortality in young stock, particularly buffalo calves. Hitherto not much attention has been focussed on this parasite and the consensus of helminthological opinion holds only *Ascaris* as a common cause of calf-mortality in buffaloes.

During the last four years the writer has been critically studying a large collection of materials of this parasite from sheep, goats, cattle and buffaloes from different localities in Bihar (India), and has made some observations on the morphology of the adult worm and its eggs, which are described below and illustrated. Recently, some evidence was derived from a post-mortem case on the significance of this parasite in causing death of a buffalo calf; and it is believed that a thorough inquiry may bring out valuable information about this parasite as a factor responsible for heavy calf-mortality in this country, particularly buffalo calves.

The adult

The morphology of the adult worm in general agrees with the descriptions furnished by previous authors. In a single specimen, collected from a sheep at Daltonganj, the arrangement of the testes showed some variations in that they were grouped in some segments in the form of two triangles, one on either side, which did not meet together in the mid-line (Fig. 1). This was the distinctive feature of the species *M. trigonophora*, proposed by Stiles and Hassall in the year 1893. Theiler [1924], doubting its specific value, states that "my experience is that the testes in *M. expansa* may be roughly arranged in two broad triangles which usually meet in the mid-line, or in a continuous band thinning slightly towards the mid-line, or they may be as numerous in the median field as elsewhere". She continues further that "all three types may be found in one individual or only one type may be present". Baer [1927] in his "Monographie des Anoplocephalidae", nevertheless, maintained this species. Taylor [1928] after examining a series of segments of several worms noted the variable nature of this character even in the segments of the same individual. His photographic illustrations are valuable in this connection. Again, Southwell [1930] described this feature in young segments of *M. benedeni*. In the present study, Taylor's observations are confirmed.

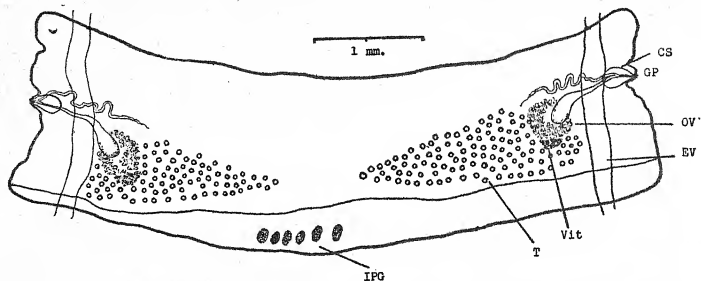


FIG. 1. Segment of *Moniezia expansa* showing arrangement of the testes, CS=Cirrus Sac ; GP=Genital pore ; OV=Ovary ; EV=Excretory Vesicle ; Vit=Vitellaria ; T=Testes and IPG=Inter-proglottidal glands.

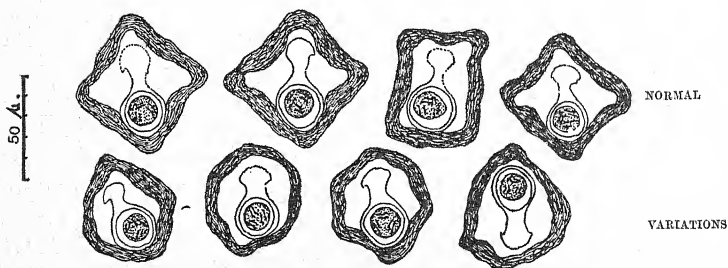


FIG. 2. Ova of *Moniezia expansa*.

The eggs

Different descriptions and measurements have been given by different authors for the eggs of *M. expansa* and the illustrations furnished by them are so varying and confusing that the laboratory man is often baffled. Baylis [1929] records that the eggs measure 0.05 to 0.07 mm. in diameter and figures them as spherical in shape. Bhalerao's [1935] measurements are 0.050-0.090 mm. for diameter and his text-figure also indicates that they are spherical in shape. But, Mönnig [1950] describes them as somewhat triangular in shape, containing a well developed pyriform apparatus, and measuring 56-67 μ . in diameter.

In the present study the fresh eggs examined in a series of faecal samples by sugar floatation method presented a different picture altogether. They were neither spherical nor triangular but had rather a rhomboidal shape, the sides of which measured 40-55 μ . and the diameter 50-65 μ . Instances of individual variations from triangular to spherical shape were met with but very rarely. These are all illustrated by furnishing camera lucida drawings [Fig. 2]. Examination of these eggs *in utero* in stained preparations of the segments did not show any uniformity or constancy in their morphology, as they were shrivelled up presenting spherical, triangular or rhomboidal shape with irregular outline, and perhaps this accounts for the variations in observations of the previous authors. Mönnig's [*loc. cit.*] figure of the egg of *M. benedeni* resembles more or less the eggs of *M. expansa* observed by the author in the present study.

Pathogenicity

A good deal of controversy exists in the available literature over the pathogenicity of this parasite and some authors believe that these worms are not harmful at all. Mönnig [1950], however, maintains that heavy infestations with this parasite are common but even one or a few worms are able to produce disease.

Lafenetre [1948], while recording an epizootic of monieziasis in sheep in France with losses ranging from 5 to 25 per cent, observed that although the infected animals were in good condition, the death was sudden. Kates and Goldberg [1949 and 1951] observed the contrary in America and found that lambs heavily infected experimentally with *M. expansa* showed no clinical symptoms or any observable injurious effect and that there was no significant retardation in growth or differences in weight. Hansen Kelley and Todd [1950], however, noticed retardation in growth and some reduction in the haemoglobin and the packed cell volume of erythrocytes, with loss in marketable weight in lambs infected experimentally with *M. expansa*. Link and his associates [1950] also supported that heavy infestation with *M. expansa* was considered to be the cause of severe loss in a calf-herd in Illinois. Harries [1953] found that in a sheep flock heavily infected with *M. expansa*, both the ewes and the lambs were in poor condition and there was some mortality.

Infection of ruminants with this parasite, particularly lambs, kids and calves is not uncommon in India. Bhalerao [1947] remarked that in India infection with *M. expansa* was very heavy in some localities and caused considerable mortality among livestock, particularly in ovines. He observed that the records of a sheep

breeding farm near Mysore showed that nearly 90 per cent lambs succumbed annually to the infection of this parasite. The infected animal shows progressive anaemic and debilitating symptoms and retardation in growth. The infection has, however, been rarely held to be of any pathological significance in buffalo calves. The following case report will illustrate its pathogenicity and significance as an etiological agent for calf-mortality in buffaloes:

"On the 5th May, 1955 five buffalo calves were brought at the Bihar Veterinary College Laboratory for some safety tests of the newly evolved Bain's H. S. vaccine. One of these died on the 11th May after showing the following daily temperatures recorded both in morning and evening. The animal was about ten months old and the general condition was suspicious of helminthiasis.

Date		Morning temp.		Evening temp.
6-6-55	..	100°F	—	102.8°F
7-6-55	..	100.4°F	—	103.2°F
8-6-55	..	100.6°F	—	102.8°F
9-6-55	..	100.8°F	—	102.2°F
10-6-55	..	100°F	—	102.2°F
11-6-55	..	97°F	—	Died at 11.45 a.m.

(The animal was given 2 c.c. of the Bain's H.S. vaccine on 9-6-55 in the neck region without any reaction.)

The general post-mortem picture was that of extreme anaemia and debility. Fats were gelatinised, the peritoneal cavity contained about 8 oz. of serous fluid and the gall bladder about 4 oz. of greenish bile. The small intestine was congested throughout and two long strobilae, measuring about 450 c.m. in length, of what was subsequently identified as *Moniezia expansa* were present. Caecum contained only a few examples of *Trichuris ovis*. The general post-mortem character suggested that the animal died of inanition due to *Moniezia* infection. Examination of smears from heart blood proved negative and the faecal sample showed numerous eggs of *M. expansa* and a few of *T. ovis*.

The remaining test-animals were then thoroughly examined for helminthiasis by regular examination of faecal samples. Three of these showed infection with *Moniezia* and it was observed that mucous flakes were often discharged with the faeces. Entangled with the mucous flakes were often found a few eggs of the parasite (*Moniezia*). The infected animals were not in proper condition.

SUMMARY

1. Some observations on the arrangement of the testes in *Moniezia expansa* are recorded with illustration in confirmation of the findings of some previous authors. This supports invalidation of the species *M. trigonophora* Stiles and Hassall, [1893].

2. An illustrated account of the morphology of the eggs of *M. expansa* is furnished in settlement of the disputed variations in their shape and size appearing in the existing text books.

3. A case of monieziasis in a buffalo calf is described to illustrate its pathogenicity and significance as an etiological agent for calf-mortality in buffaloes.

ACKNOWLEDGMENT

The author is thankful to Shri D. N. Sahay and Shri S. M. Hadis of the Bihar Veterinary College Laboratory for kindly affording an opportunity to study the cases of monieziasis in buffalo calves.

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IN-VITRO TRIALS OF SOME NEW ANTI-TUBERCULOUS COMPOUNDS—I*

By M. R. DHANDA, GAJINDAR SINGH, M. P. KHARE and J. M. LALL

(Received for publication on December 1, 1955)

SINCE the early days of the empirical use of salts of heavy metals in human medicine, for combating infection due to *Mycobacterium tuberculosis*, much progress has been witnessed in the chemotherapy of this disease. Each promising compound is now assessed quantitatively for its activity in the test-tube and in experimental animals before being introduced to the veterinary and human medicine. According to Hart, the pioneer work on these lines against *tubercle bacillus* was started with the experimental trial of sulphanilamide by Rich and Follis [1938]. The large volume of literature on this subject that has since accumulated has equipped the clinician with more effective weapons for fighting the scourge, e.g. TB1 (p-acetamido-benzaldehydethiosemicarbazone), PAS (para-amino-salicylic acid), INH (iso-nicotinic acid hydrazide), etc. None of the compounds synthesised so far can, however, rid the system of all the bacteria responsible for the disease and, consequently, quest for more effective drugs against tuberculosis continues.

In his search for more efficient anti-tuberculous compounds, the chemist has, among other things, been guided by the revelation of the chemical structure of the *tubercle bacillus* itself. The presence of fatty acids in the superficial layer of the bacillus led Robinson [1940] to conjecture the suitability of lipophilic and basic compounds as potent remedies against tubercular infection. With the same object in view the authors have tested *in-vitro* the anti-tuberculous activity of several 4-acyl-4-aminodiphenyls and their N-4-diphenyl amidines. Ortho, meta and para-cresotinic acid hydrazides and their substituted N'-benzylidene derivatives have also been tested in pursuance of the findings of Bun Hoi [1952] in respect of anti-tuberculous properties of non-pyridinic hydrazides, especially in the hope of being able to correlate their structural features with activity.

Although the authors are aware of the absence of quantitative relationship between the *in-vitro* and *in-vivo* activities of drugs against infective agents; trials in guinea-pigs were, like many other workers, omitted in the preliminary stage in order to conserve time, funds and labour.

MATERIAL AND METHOD

The bacteriostatic properties of these compounds were studied on floating culture pellicles, the use of submerged cultures for the purpose having been abandoned for want of adequate number of colorimetrically matched tubes.

*Work conducted under the aegis of the Indian Council of Agricultural Research.

The synthetic medium employed for these trials had the following composition :

I-Asparagin	14.0 gm.
Dipotassium phosphate ($K_2 HPO_4 \cdot 3H_2O$)	1.8 gm.
Sodium citrate ($Na_3 C_6 H_5 O_7 \cdot \frac{1}{2} H_2O$)	0.9 gm.
Magnesium sulphate ($Mg. SO_4 \cdot 7H_2O$)	1.5 gm.
Ferric citrate scales	0.3 gm.
Dextrose	10.0 gm.
Glycerol C. P.	100.0 gm.
Distilled water	upto 1 litre
Reaction : PH7.	

Sterilisation by autoclaving at 11 to 12 lb. for 25 minutes.

As all the compounds synthesised were sparingly soluble in water, they were added to the medium in the form of suspensions obtained by triturating 50 mgm. of each separately in 5 ml. quantities of 0.15 per cent aqueous agar solution and sterilising in an autoclave at 10-11 lb. pressure for 25 minutes. 1 ml. of the suspension was added, with sterile precautions, to 99 ml. of the synthetic medium contained in each flask. Two sets of trials were put up, in duplicate, one without agar and the other with 0.15 per cent agar incorporated in the medium to render it more viscous so as to increase its capacity for holding insoluble particles in suspension; control flasks without drugs as also with known anti-tuberculous drugs, like INH, were kept in each series for comparison.

The culture of *Mycotuberculosis* used for this trial was of the strain PN, a human, virulent type maintained at this Institute for tuberculin preparation and passaged occasionally through guinea-pigs for retaining virulence. Young (12 days' old) vigorously growing culture in the form of a thin surface pellicle on glycerine broth was used for seeding the experimental and control flasks. So far as possible, uniformity in the size of inoculum in each flask was aimed at.

RESULTS

Comparative observations against drug-free controls were made at weekly intervals for three weeks and the results are presented in Table I. It will be seen that compounds No. 9, 13, and 18 compared favourably with p-amino- α -phenyl pyridine and INH* in their *in-vitro* anti-tuberculous activity, while compound 1 tended to approach that limit.

*Isonex (Dumex) tablets of 50 mg. each were used for this trial.

At the end of five weeks of incubation, almost the entire inoculum from each of the flasks containing compounds No. 9, 13, 18, 35 and 36 was transferred to fresh flasks of drug-free synthetic medium, in order to know if some of the bacilli were still viable, a possibility to be expected only in the event of drug inhibition being partial. Subcultures were, at the same time, also made from control flasks without drugs for comparative study. The results observed at the end of a month and a half of incubation are indicated in Table II.

The efficacy of compounds No. 1, 9, 13 and 18 showing an appreciable inhibition at 10 mg. per cent dilution, was also tested in varying concentrations *vis a vis* INH and PAS; the results obtained are given in Table III.

DISCUSSION

Perusal of Tables I and III indicates only 4'-Butyro-4-aminodiphenyl (Lab. Ref. No. 13) to be as effective as INH or PAS in dilutions up to 1 : 100,000, whereas three other compounds (Lab. Ref. Nos. 1, 9 and 18) compare favourably with them in somewhat lower dilutions (i.e. up to 1 : 40,000). It is apparent that the suitability of any of these chemotherapeutic agents for clinical application will largely depend on their concentration levels permissible in the body, without producing toxic symptoms and that they will have to be rendered water soluble for the purpose, by introducing hydrophilic groups, even at the risk of possible reduction in activity. It cannot, however, be ignored that these trials have got to be evaluated at a credit for the disadvantage of lack of easy diffusion through the medium on account of low solubility as also for the larger molecular structures of these compounds, as compared to INH and PAS, which do not allow the production of comparable molar concentrations at each W/V dilution.

An anomaly in the results, set out in Table I is also worth consideration. Contrary to expectation, the medium in which agar had been incorporated for keeping the drugs in a uniform suspension did not prove better than the agar-free medium; in most of the cases it allowed better growth of *Myc. tuberculosis*, indicating thereby, a lower drug activity. The authors consider one or both of the following possibilities to be responsible for this phenomenon :—

(i) Agar, by virtue of increasing the viscosity of the medium, reduces the diffusibility of the drugs.

(ii) The presence of agar provides an alternative surface for drug absorption.

Although protracted trials of the kind presented in Table II do not give any idea as to the bactericidal nature of the compounds tried, because of the natural death of a stationary population due to inanition, they do reflect on the degree of bacteriostasis induced. Only compounds No. 13 and 18 seem to have completely inhibited the growth of *Myc. tuberculosis* in 10 mgm. per cent dilution. *In-vivo* trials will, however, be conducted with the soluble derivatives of all the 4 compounds (Nos. 1, 9, 13 and 18).

It has not been possible to establish any correlation between the basicity and lipophilic nature of compounds and their anti-tuberculous activity, which seems to depend largely on individual molecular structure.

TABLE I
Showing the in-vitro anti-tuberculous activity of the compounds

Lab. Ref. No.		Name of Chemical	Amount of growth (including inoculum) on the						Remarks	
			8th day of incubation		15th day of incubation		22nd day of incubation			
			Agar medium	Plain medium	Agar medium	Plain medium	Agar medium	Plain medium		
1		4'-Aceto-4-aminodiphenyl	+2	+2	+5	±3	+15	±4	Activity almost approaching that of INH	
2		4'-Aceto-N-4-diphenyl benzamide	+2	+1½	+5	±2	+15	+5		
3		4'-Aceto-N-4-diphenyl-0-tolylamide	+2	+1½	+3	±2	+8	+4		
4		4'-Aceto-N-4-diphenyl-m-tolylamide	+1½	+1½	+3	±2	+14	+7	Similar to INH	
5		4'-Aceto-N-4-diphenyl-p-tolylamide	+2½	+2½	+4	+4	+13	+15		
6		4'-Aceto-N-4-diphenyl-3:4-xylylamidine	+2½	+2½	+2	+3	+3	+13		
7		4'-Aceto-N-4-diphenyl-p-anisoylamidine	+1½	+1½	+2	±3	±3	+8	Similar to INH	
8		4'-Propio-4-aminodiphenyl	+1½	+3	±8½	±6	+14	+16		
9		4'-Propio-N-diphenyl-0-tolylamide	+2	+3	+4	±6	+16	+18		
10		4'-Propio-N-4-diphenyl-m-tolylamide	+1½	+3	±6	±3	+15	+8	Similar to INH	
11		4'-Propio-N-4-diphenyl-p-tolylamide	+3	+2	±2	±2	±6	±6		
12		4'-Propio-N-4-diphenyl-p-anisoylamidine	+3	+1½	±2	±2	+12	+4		
13		4'-Butyro-4-aminodiphenyl	+3	+1½	±2	±2	+4	±4	Similar to INH	
14		4'-Butyro-N-4-diphenyl-m-tolylamide	+1½	+1½	+3	±2	+7	±4		
15		4'-Butyro-N-4-diphenyl-p-tolylamide	+1½	+1½	+2	±2	±4	±4		
16		4'-Butyro-N-4-diphenyl-p-anisoylamidine	+1½	+1½	±2	±2	±4	±4	Similar to INH	
17		Ortho Cresotin hydrazide								
<i>Substituted N-benzylidene derivatives of o-cresotin hydrazide (in the benzophenone residue)</i>										
18		o-OH	+1½	+1½	±3	±1½	±10	±2	Similar to INH	
19		p-OMe	+1	+1	±3	±1½	+12	+12		
20		p-NMe ₂	+1	+1	±3	±1½	±2	±2		
21		Cinnamylidene								

Substituted X'-benzylidene derivatives of o-cresotin hydrazide (in the benzylidene residue)

TABLE I—*contd.*
Showing the in-vitro anti-tuberculous activity of the compounds

Lab. Ref. No.	Name of Chemical	Amount of growth (including inoculum) on the						Remarks
		8th day of incubation		15th day of incubation		22nd day of incubation		
		Agar medium	Plain medium	Agar medium	Plain medium	Agar medium	Plain medium	
<i>Substituted N-benzylidene derivatives of o-cresotin hydrazide (in the benzylidene residue)</i>								
22	Piperonylidene	+	+	+	+	+1½	+12	+6
23	Meta Cresotin hydrazide			+2	+1½	+5		+3
<i>Substituted N-benzylidene derivatives of m-cresotin hydrazide</i>								
24	o-OH	+2	+	+3½	+2	+12		+5
25	p-OMe	+2	+2	+4	+4	+11		+11
26	p-NMe2	+2	+2	+3	+3	+13		+11
27	Cinnamylidene	+2	+2	+4	+4	+15		+13
28	Piperonylidene	+1½	+1½	+2½	+2½	+7½		+7
29	Pure Cresotin hydrazide	+1½	+2	+2½	+2½	+6		+4
<i>Substituted N-benzylidene derivatives of p-cresotin hydrazide</i>								
30	o-OH	+	+	+2	+1½	+5		+4
31	p-OMe	+1½	+2	+4	+4	+14		+14
32	p-NMe2	+3	+2	+7	+4	+16		+13
33	Cinnamylidene	+1½	+1½	+4	+3	+14		+14
34	Piperonylidene	+2½	+2½	+7	+5	+20		+13
35	p-amino-phenylpyridine	+	+	±	±	—		—
36	Isonicotin Hydrazide	+	+	±	±	—		—
37	Controls without drugs	Not put up	+3	Not put up	+6	Not put up		+16

Notes: (1) Date of culturing—7-7-54 (observations made on the 15th, 22nd and 29th July, 1954).
 (2) Numerals after the sign + indicate the extent of growth (e.g. +3½ is to be taken as +++±).
 (3) One plus in the first observation approximates to the size of the inoculum.

TABLE II
Showing the results of viability tests after five weeks of incubation on 10 mg. per cent drug concentration

Description of flasks from which culture attempted	Date of subculture on drug-free medium		Date of observation	Growth observed	Remarks
Compound No.	With	Without agar			
9	Without agar		12-8-54	Profuse growth	Resembling control flasks.
9	With agar		do	Slight growth	About 3 sq. cm. in area
13	Without agar		do	No growth	Inoculum still floating
13	With agar		do	do	do
18	Without agar		do	do	do
18	With agar		do	do	do
35	Without agar		do	do	do
35	With agar		do	Growth present	About 12-15 sq. cm. in area.
36	Without agar		do	No growth	Inoculum floating.
36	With agar		do		
Not available for subculture due to contamination					
Control—Without drug	Without agar		12-8-54	Profuse growth	
Control—Without drug	Without agar		do	do	

TABLE III

Showing the in-vitro anti-tuberculous activity of compounds No. 1, 9, 13, and 18 vis a vis INH and PAS at varying dilutions

Compound No.	Date of inoculation	Date of observation	Amount of growth at various drug concentrations					Remarks
			10 mg. per cent	7.5 mg. per cent	5 mg. per cent	2.5 mg. per cent	1.0 mg. per cent	
1	8-12-54	{ 18-12-54 28-12-54	+	+	+	+	+1½	Comparable with INH and PAS.
9		{ 18-12-54 28-12-54	+	+	+	+	+	
13		{ 18-12-54 28-12-54	+	+	+	+	+	
18		{ 18-12-54 28-12-54	+	+	+	+	+	
INH		{ 18-12-54 28-12-54	+	+	+	+	+	
PAS		{ 18-12-54 28-12-54	+	+	+	+	+	
Control		{ 18-12-54 28-12-54	+++	+++	+++	+++	+++	
			+++	+++	+++	+++	+++	

One + at first observation indicates almost the size of the inoculum.

SUMMARY

Thirty-four compounds have been tested *in-vitro* for their anti-tuberculous activity, only four of which have shown promise; correlation of their lipophilic nature and basicity with activity could not be established.

ACKNOWLEDGMENT

The authors are thankful to Dr V. S. Misra, Lecturer, Department of Chemistry, Lucknow University for his keen interest in this work and to Shri B. R. Sen Gupta for technical assistance.

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LUMBAR PARALYSIS IN SHEEP AND GOATS

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(Received for publication on April 5, 1955)

AN obscure disease has been occurring amongst sheep and goats at the Government Livestock Farm, Hissar almost every year since 1944. It was, however, observed for the first time in 1935 at the farm. The disease is of seasonal occurrence and prevails from the beginning of September to the end of November or beginning of December. All breeds of sheep, i.e. Bikaneri, Hissari and Lohi and all breeds of goats, Betal, Hill, Desi and Angora maintained at the farm were found affected irrespective of the age of the animal.

Symptoms

The symptoms observed in affected cases are : Staggering gait, inco-ordination of movement of hind legs which are carried wide apart, weakness, lying down, inability to stand and general dullness. The animal seems to be drunk and reels to and fro. There is no appreciable rise of temperature. It may be subnormal in advanced stages of the disease. The animal keeps on feeding even when lying down, if hand fed. There is generally no irregularity of the bowels nor complete loss of sensation of any part. The course of the disease is protracted and varies from one to three weeks. In later stages the affected animal keeps on lying in a very helpless condition and one generally thinks that it would die during the night but it lingers on for a number of days.

Post-mortem lesions

Post-mortem lesions show engorgement of the blood vessels of brain, congestion of the brain substance and spinal cord. The pia mater shows pin point haemorrhages. In chronic cases, both in sheep and goats, there is appreciable inflammation of the abomasum and of the small intestines. Kidneys in some cases show congestion. Heart, lungs and liver are usually normal.

Little is known about nervous diseases of sheep and goats. The literature on this subject has been reviewed by Innes [1950]. Emoto [1923] reported paralysis among goats in Japan which occurred from 1911 to 1924 amongst animals as imported from Switzerland. He mentioned that the disease has been seen each year in the late summer and autumn and that adult animals were usually affected. He designated the condition as a non-purulent lymphocytic meningitis with cerebro-spinal malacia. Crawford [1939-42] made observations on a disease of goats known as "Lumbar Paralysis" which occurred in Ceylon amongst animals imported from India or their progeny. He reported that there was motor weakness and posterior inco-ordination and the onset of the disease was sometimes dramatically sudden ; there was no rise of temperature in affected cases and that the course of the disease was either acute or subacute. He could neither transmit the disease by sub-cutaneous or intramuscular inoculation of brain and cord emulsions into healthy goats, rabbits, guinea-pigs and mice, nor observe growth of any pathogenic organism on cultural examination of blood, spinal cord and brain of the typical cases. Further

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work in Ceylon by Pillai, Mahmooth and Malkani [1950] confirmed Crawford's findings and revealed that the disease affected a variety of Indian breeds imported into Ceylon—Jamnapari, Sindhi, Kamoris, Alandi, Bengalori and in crosses between these and local Ceylon goats. Gill [1931] reported the incidence of circling disease in sheep in New Zealand due to *Listerella Erysipelothrix monocytogenes*. King [1940] described an outbreak of listerellosis in goats in the U.S.A., as disseminated encephalomyelitis with granulomatous lesions almost restricted to the brain stem, the changes were regarded as a variety of myelin loss. Olafson [1940], Gifford and Eveleth [1942] and Kaplan and Lager [1945] reported isolated cases of listerellosis in the U.S.A. Annual reports of the Indian Veterinary Research Institute [1932-42] show that Caprine Paralysis existed in India and that the disease could not be successfully transmitted. The histopathological examination of cerebral cortex and spinal cord showed meningeal congestion and haemorrhage, perivascular infiltrations, neuronophagia, and destruction of nerve cells. The exact etiology of the disease could not, however, be established. The possibility of the disease being due to poisoning with *Lathyrus sativus* or some other fodder poisoning was excluded by Crawford *loc. cit* by feeding experiments with a variety of plants. Streptococcal infection was at one time considered to be the cause of the condition but later experimental work did not support this view. Yanagiwa, Shoho, Tanaka *et. al.*, [1941-47] attributed this condition to injuries to the brain and spinal cord by immature *Setaria digitata* and termed this condition as *Setariosis*. Innes, Shoho and Pillai [1952] reported pathological studies on this condition and supported the Japanese workers' viewpoint. Iyer and Seetharaman [1953] attributed cases of bovine paraplegia in the Madras State as due to a deficiency of calcium and magnesium, particularly the latter.

Investigation

The disease occurring amongst sheep and goats at this farm has been studied from different aspects:

(1) Smears from blood, spleen, liver, kidneys, brain and spinal cord of the affected cases on microscopical examination did not show the presence of any pathogenic organisms or protozoan parasite. Materials from these organs and blood sown on broth, plain agar, blood agar and Robertson's medium were also found to be sterile.

(2) Several attempts were made from year to year to transmit the disease into healthy sheep, goats and laboratory animals by injecting brain emulsion, spinal fluid and blood by different routes but all failed. The Assistant Research Officer, Disease Investigation Section, Indian Veterinary Research Institute, Izatnagar, visited this farm in 1948 and conducted necessary trials to transmit the disease but no conclusive results were achieved. He sent spinal fluid on ice in thermosflask to the Research Officer, Disease Investigation Section, Indian Veterinary Research Institute, per special messenger for transmission experiments but the disease could not be reproduced.

(3) Once it was suspected that this condition may be due to the animal eating certain poisonous weeds and grasses. A botanist from the Forest Research Institute, Dehra Dun visited the farm and collected 102 samples of different weeds and grasses for examination. He reported the following weeds and grasses to be poisonous :

(i) *Datura* (ii) *Lycium europelm* (iii) *Solanum melingen* (iv) *Xanthium strumerium* (v) *Andropogon-Janvaranous* (vi) *Cardospermum habiacavum* (vii) *Farsattia-Jaequerontin* (Seed poisonous) (viii) *Fluggo-virisa* (ix) *Fribulus ferrestris* and (x) *Sorghum helipensi*.

Accordingly pieces of spleen, liver, kidneys and stomach wall and stomach contents from a number of cases that died of the disease were sent to the Chemical Examiners of the Punjab and Uttar Pradesh Governments but no poison could be detected in any of the materials sent.

(4) Pieces of brain and spinal cord from three cases of the disease on histopathological examination at the Indian Veterinary Research Institute, Izatnagar, revealed changes associated with *encephalomyelitis* such as *haemorrhagic foci*, *neuronophagia* and nerve cell degeneration. The whole brain and long pieces of spinal cord from different parts of the vertebral column of a typical case of the disease were also sent to the Research Officer, Disease Investigation Section, Indian Veterinary Research Institute, Izatnagar for detailed histopathological studies as desired by Innes. The changes observed were :

Cerebrum. Congestion, focal necrosis and slight but distinct neuronophagia. There was congestion of the membranes as well.

Cerebellum. Capillary congestion and slight but distinct neuronophagia.

Medulla oblongata and spinal cord. There was only slight congestion. No neuronophagia could be detected. Careful examination of sections from various parts proved negative for helminthic infection.

On the other hand similar examination of the pieces of brain and spinal cord from four other typically affected cases failed to reveal any of the above mentioned pathological changes.

(5) The Research Officer, Disease Investigation, Indian Veterinary Research Institute, on the basis of early histopathological studies felt that the disease might be of virus origin. He, therefore, advised vaccination of healthy stock with a 4 per cent carbolised brain emulsion prepared from the brain substance of a typical case of the disease destroyed in extremis. One hundred and twenty-six goats and 108 sheep were vaccinated with the above vaccine in three batches during the years 1950-53. An equal number of these animals of the same age-group were kept as controls under identical conditions of feeding and management for comparative study. Results judged on 150 vaccinated animals showed that ten cases of the disease occurred in the two groups, six in the vaccinated and four in the control group. It was also noticed that one animal, male goat No. 515, which suffered from the disease in 1950 in spite of the vaccination, had a second attack in 1951 and a third attack in 1952. The third attack was as severe as the second. This work showed that vaccination had no good effect and that one or more attacks of the disease did not confer any protection against a subsequent attack.

(6) The possibility of the disease being due to *Listerella* infection was reasonably excluded by subjecting serum samples from 11 recovered cases of the disease to agglutination test for listerellosis at the Indian Veterinary Research Institute, Mukteswar. Nine samples proved negative and two gave doubtful reaction when tested with antigen prepared from Mukteswar stock *Listerella* culture.

(7) Attempts were made to grow the so called virus of the disease on chorion-allantoic membrane of the developing chick embryo. The material was passed in four passages. No satisfactory and uniform results could be achieved. There were no lesions on the embryos after death. There was only congestion and haemorrhage in some cases.

(8) In view of the fact that the disease could not be transmitted in spite of repeated experiments, and that it appeared in the vaccinated animals, it is likely that the disease in question is not of virus origin. The inability to demonstrate any bacteria in blood, brain substance, and cerebrospinal fluid by microscopical, cultural and serological tests excludes the possibility of a bacterial infection. Negative results on chemical analysis of samples of fodder fed to these animals, and viscera from affected cases point to the absence of any fodder or other poisoning.

In consideration of the above observations coupled with clinical symptoms shown by the affected cases and findings of Johnson, Hamilton, Nevens and Boley [1948] recording more or less similar condition in the calf due to thiamine deficiency, it was suspected that the disease in question may be a vitaminosis B₁. It was, therefore, considered desirable to give a trial to thiamin administration. Sixteen cases of the disease (11 caprine and 5 ovines) were divided into two groups with 8 animals in each group. Animals in group No. 1 were treated with vitamin B₁ (Berin), a preparation of Glaxo Laboratories (India) Ltd., by intramuscular route and by mouth. Animals in group No. 2 were not given any treatment. Animals in both the groups were kept in the hospital under identical conditions of feeding and management. Seven animals (4 caprine and 3 ovine) got cured in group No. 1. Out of the 7 cured cases, one goat had a relapse about one month after the treatment and died. In group No. 2, 7 animals died and one recovered without any treatment.

The results are tabulated below :

Group of animals	No. of animals	Cured	Died	Percentage recovery
1. Vitamin B ₁ treated	8	7*	1	87.5
2. Non-treated	8	1	7	12.5

*One goat out of seven cured cases had a relapse one month after the treatment and died.

The line of treatment consisted in the intramuscular administration of 1 c.c. of Berin, 100 mg. each c.c. daily for the first 6 days followed by 1 c.c. of Berin on alternate days during the second week. The animals were given orally 6 Berin tablets, 10 mg. each tablet on the days when no injections were given.

Ordinarily the cases recovered after the first 6 injections. Some required treatment during the second week. The treatment was, however, continued for two weeks. It was purposely given for a longer time to avoid occurrence of any relapse. The above doses were for adult animals. For young kids and lambs, the doses were reduced accordingly.

The results obtained in the above trial were encouraging and warranted further work in this direction. Consequently 28 more cases were given the above treatment during the period from 1950 to 1953. Out of these 28 cases thus treated, 22 made complete recovery, two showed partial improvement and four died. These results indicate that vitamin B₁ has some part to play in the causation of the disease. It is believed that vitamin B is normally synthesised in the rumen of ruminants and, therefore, it is contended that ordinarily there is no deficiency of this vitamin in the polygastric animals. It is likely that some factors such as deficiency of trace elements like copper, cobalt and iron may be interfering with the normal synthesis of vitamin B complex in these animals.

(9) Accordingly a mixture consisting of cobalt sulphate 20 mg., copper sulphate 20 mg. and ferrous sulphate 100 mg. was administered once every week for 6 months from 1st April to 30th September for two consecutive years to a total of 92 lambs, 30 Betal goats and 20 Betal kids. An equal number of these animals were kept as controls under identical conditions of feeding and management for comparative study. The results were judged at the end of the usual season of the disease and it was observed that 12 animals from the two groups developed the disease, three from the treated and 9 from the untreated group. These observations indicate that deficiency of the above trace elements may be playing some role in the causation of the disease. To obtain direct evidence in this direction, five samples of suspected fodder obtained from the grazing fields of Chhaoni block and Goat Breeding Section were sent to the Head of the Division of Animal Nutrition, Indian Veterinary Research Institute, Izatnagar for estimation of their copper, cobalt and iron contents. Results received in respect of two samples showed that there was a definite deficiency of copper in one sample and cobalt content in it was on the border line.

(10) The effect of feeding grain ration—a rich source of vitamin B—at one pound per goat per day, for 6 months from 1st June to 30th November, on the incidence of lumber paralysis was studied on 32 goats. A similar number of these animals of identical age-group were kept as controls for comparative study. Four animals from the two groups developed the disease, one from the grain-fed-group and 3 from the control group.

(11) The prophylactic value of Diethyl carbamyl-4 methyl piperazine citrate—"Hetrazan" (a preparation of Lederle Laboratories), prescribed by Shoho [1952], was studied on 37 male kids, 25 goats and 6 lambs of this farm. A similar number of these animals, of the same age-group and kept under identical conditions of feeding and management, were left as controls. The dose given was 20-30 mgm./kg. of body weight. The drug was administered about 20 days before the usual time of occurrence of the disease. Results obtained showed that two cases of the disease, one in each group were encountered amongst the experimental animals.

Work so far carried out here indicates that deficiency of vitamin B₁ in sheep and goats plays some part in the etiology of lumbar paralysis. It has not been possible to establish so far as to whether the deficiency is primary, i.e. as a result of deficiency of the vitamin in the fodder or is secondary, i.e. due to some factors causing interference in the vitamin B complex in the rumen of the animals. The possibility of trace elements, copper, cobalt and iron has been explored and it appears that copper and cobalt may be the factors responsible for interfering with the vitamin B synthesis in rumen of the affected animals.

SUMMARY

1. An obscure disease occurring amongst sheep and goats at the Government Livestock Farm, Hissar has been described.
2. The results obtained with administration of thiamine in the treatment of clinical cases of the disease have been reported to be encouraging.
3. The effect of administration of trace elements, copper, cobalt and iron, on the incidence of the disease has been studied and it appears that a deficiency of trace elements plays some part in the causation of the disease.
4. It has neither been possible to isolate any pathogenic organism from the affected cases, nor the disease could be reproduced in sheep, goats and laboratory animals.

ACKNOWLEDGMENT

The authors feel indebted to Shri B.N. Handa, Director Animal Husbandry and Warden of Fisheries, Punjab, Simla for useful suggestions, to Dr Tulsa Ram, Veterinary Investigation Officer, Punjab, Hissar for continuous interest and advice during the course of investigation and to Shri M.R. Dhandra, Head of the Pathology and Bacteriology Division, Dr N.D. Kehar, Head of the Division of Animal Nutrition and Shri P.R.K. Iyer, Research Officer, Disease Investigation, Indian Veterinary Research Institute, for guidance and examination of the materials sent to them.

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ACUTE THEILERIASIS IN SHEEP

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(Received for publication on February 12, 1955)

A perusal of the available literature on the subject of theileriasis in sheep indicates that only two species of *Theileria* parasites have so far been recorded in sheep and goats and designated as *Theileria ovis* and *Theileria herci*. The former parasite is considered non-pathogenic because it does not produce any clinical symptoms of disease while the latter is associated with a definite and recognisable fatal disease. In *Theileria herci* infection, besides the small ring or rod shaped parasites in the red blood cells of sheep and goats, structures which are interpreted as Koch's blue bodies have been encountered in blood and organs including bone-marrow.

During the monsoon frequent deaths at the Mahbubnagar Farm occurred in sheep and the Manager who was unable to diagnose the cause of death sought the help of the senior author who visited the place of outbreak and examined the (11) ailing cases. On examination of blood smears it was found that the cause of death was acute theileriasis. These theilerial parasites were found along with Koch's blue bodies, both free and in the large mononuclear leucocytes, in the blood smears.

A lamb of about one year age was sub-inoculated intravenously with 20 c.c. of blood direct from an ailing case showing high temperature and theilerial parasites with Koch's blue bodies in the circulatory system. This lamb reacted after 16 days and the strain has been maintained in the laboratory.

The article is a preliminary note and the detailed experiments covering all the aspects with regard to modes of infection, treatment, method of immunisation, preventive measures, etc. are on hand and are being worked in greater detail and the data accruing on this will form the subject matter of a further detailed report.

With a view to find out the host specificity of the strain, 6 goats, 2 buff-calves and one cow-calf were sub-inoculated intravenously with 20 c.c. of blood, but all these animals proved refractory to infection, whereas all the sheep sub-inoculated simultaneously along with these animals in batches on different dates with the same strain had reacted and succumbed to the disease, proving thereby that the strain is specific only to sheep. Two rabbits and two guinea-pigs which also received 5 and 3 c.c. of virulent blood respectively did not react.

According to literature the pathogenic strain of theileria, viz. *Theileria herci*, is a parasite which affects both sheep and goats. But the strain, which we have on hand, appears to distinguish itself from *Theileria herci* in being specific to sheep only in our host specificity experiments conducted so far. At first we hazarded to call it a new strain, of which there seems to be very little doubt, yet we refrain to call it so until we complete our programmed work on all aspects.

Sulphamezathine 33 1/3 per cent when inoculated intravenously in doses of 5 to 7 c.c. supported daily by half the initial dose, gave roughly 70 per cent recoveries. Few deaths which could not be avoided in the apparently recovering cases about one week after their reaching normal temperature were due to extreme emaciation and damage caused by the disease to the vital organs like liver, spleen, kidneys and lymphatic and alimentary systems and aggravated by heavy worm burden. These cases were microscopically negative for the presence of the parasites on death.

The disease could be controlled satisfactorily by resorting to dipping and Copper's dip, a patent, was utilised in the field for this purpose. Two varieties of ticks have been collected off the ailing sheep and these are (i) *Hyalomma savignyi* (Gervais, 1844) and (ii) *Rhipicephalus haemaphysaloides* (Supino), the former being predominant. Experiments are designed to transmit the disease through the agency of ticks and their progeny to see whether one or both the species of the above mentioned ticks are vectors in this disease.

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CYTOLOGICAL, PHYSIOLOGICAL AND CHEMICAL STUDIES OF EGYPTIAN BUFFALO BLOOD

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(Received for publication on June 8, 1955)

(with one Text-Figure)

THE comparative study of the normal values of blood constituents and the physiological variations which occur in the absence of any definite pathological condition, is of great academic and practical importance for clinical hematology and animal husbandry especially in the tropics, since certain blood components are related to heat tolerance, environmental stress and disease immunity.

Normal hematological values vary considerably amongst different classes of farm animals. In general the erythrocyte count is inversely proportional to the body size of the species. In man, horse, swine, dog and cat the neutrophils are the most frequent leucocytes while in ruminants, laboratory rodents and chicken the lymphocytes are predominant [Olsen, 1937].

In this respect the hematological values of the Egyptian buffalo *Bos*, (*Bubalus*), *bubalis*, L. were determined.

MATERIAL AND METHODS

Experimental animals

Thirty healthy adult Egyptian buffalo-cows aged from three to ten years were available at the Animal Production Research Farm, Faculty of Agriculture, University of Cairo, Giza. Blood samples were taken for the cytological, physiological and chemical studies during the period from January to April, 1953.

Technique

1. *Cytological studies.* Four smears were prepared from each blood sample. They were stained with Delafield Hematoxylin and Eosin, Giemsa stain, Wright's stain and Leishman's stain. The corpuscle diameters were measured using the stage micrometer and the micrometric eye-piece. A Thoma-Zeis hemocytometer was used for the erythrocyte and leucocyte counts.

2. *Physiological studies.* The specific gravity of the whole blood was measured using the copper sulphate method of Weises [1950], the pH number using "Beckman" pH meter, the sedimentation rate after one hour in "Westergren" pipettes and the clotting time using "Sabrazs" capillary tubes. Hemoglobin content was determined colorimetrically using a "Halden" hemoglobinometer and the hematocrit using "Wintrobe" tubes in a centrifuge of 3000 rotations per minute for 30 minutes.

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3. *Chemical studies.* Whole blood sugar was determined using the method of Folin and Wu, [1920], the plasma proteins and the non-protein-nitrogen fractions using the technique of Van Slyke and Cullen [1914], plasma sodium using the uranyl-zinc-acetate method of Weinbach [1935], potassium using the technique of Looney and Dyer [1942], calcium using that of Roe and Kahn [1929] and phosphorus using the technique of Fiske and Subbaraw [1925].

RESULTS

The average diameter and the differential count of the blood cells from normal healthy animals are shown in Table I (see also Fig. I).

TABLE I
Cytological constants of the blood

Blood cell	Average diameter (microns)	Count/mm. cu.	
		Range	Average \pm S.D.
Erythrocytes	5.5	5.75×10^6 — 7.5×10^6	$6.8 \times 10^6 \pm 0.517$
lymphocytes	6.8		
Leucocytes	15.7	5.6×10^3 — 0.0×10^3	$6.7 \times 10^3 \pm 0.679$
monocytes	11.3		
neutrophils	11.8		
eosinophils	11.8		
basophils	11.8		

The specific gravity of the whole blood ranged from 1.050 to 1.070 with an average of 1.058 gm./ml. The pH number varied within narrow limits of 7.35 to 7.60. The sedimentation rate after one-hour period ranged from 2 to 8 with an average of 6 mm. while the clotting time ranged from 6.0 to 7.25 minutes with an average of 6.75 minutes. Hemoglobin content ranged from 11.04 to 15.18 gm. per 100 ml. of blood with an average of 12.98 gm. The hematocrit value ranged from 38 to 52 per cent with an average of 44.3 per cent (Table II).

TABLE II
Physiological constants of the blood

Items	Unit	Range	Mean \pm S.D.	C.V. per cent
Specific gravity	gm./ml.	1.05-1.07	1.058 \pm 0.012	1
pH		7.35-7.60	7.45 \pm 0.033	0.5
Sedimentation-rate	mm./1 hr.	2.00-8.00	6.00 \pm 1.65	29
Clotting time	min.	6.00-7.25	6.75 \pm 0.065	1
Hemoglobin	gm./100 ml.	11.04-15.18	12.98 \pm 1.236	10
Hematocrit	percentage	38-52	44.3 \pm 3.028	7

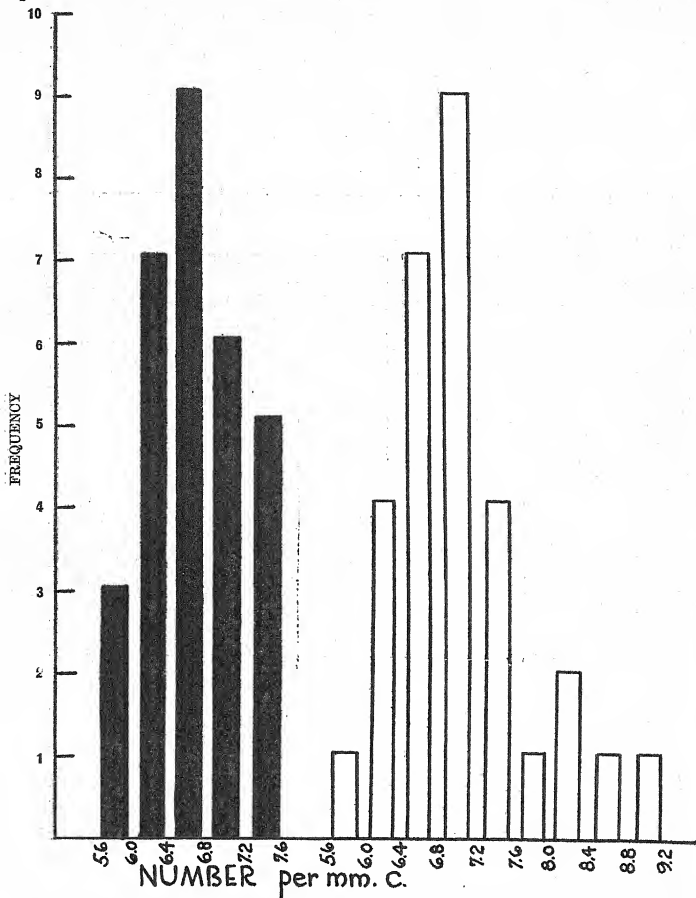


FIG. 1 Frequency distribution of blood counts in 30 healthy buffalo cows. Black columns indicate erythrocytes $\times 10^{-6}$ and white columns indicate leucocytes 10^{-3}

Blood sugar per 100 ml. ranged from 72 to 90 mg. with an average of 81.4 mg., while plasma proteins ranged from 6.82 to 7.68 with an average of 7.43 gm./100 ml. plasma. The total non-protein nitrogen per 100 ml. blood ranged from 25 to 42 mg. The average amounts of sodium, potassium, calcium and phosphorus per 100 ml. plasma were 415, 26, 10 and 28 mg. respectively (Table III).

TABLE III
Chemical constants of the blood

Items	Unit	Range	Mean \pm S.D.	C.V. per cent
Sugar	mgm./100 ml.	72-90	81.4 \pm 3.411	4
Plasma proteins	gm./100 ml.	6.82-7.62	7.43 \pm 0.266	4
Plasma non-protein nitrogen.	mgm./100 ml.	25-42	36 \pm 3.142	8
Plasma sodium	mgm./100 ml.	400-430	415 \pm 6.53	2
Plasma Potassium	mgm./100 ml.	23-29	26 \pm 1.00	3
Plasma calcium	mgm./100 ml.	9-11	10 \pm 0.156	2
Plasma phosphorus	mgm./100 ml.	26-31	28 \pm 1.032	3

DISCUSSION

The blood picture of the animal is a result of an interaction between environmental and hereditary and nutritional factors. The blood corpuscles of the buffalo possess the same staining affinity as that of other mammals. The neutrophils, eosinophils and basophils are similar to those of cattle in shape and granulation. Neutrophilic granules are spherules, different from those of chicken where they are large and elongated and from those of guinea pig and rabbit where they are rod-shaped. Eosinophilic granules are round-shaped and larger than those of neutrophils but still smaller than the specific eosinophilic granules of the horse. The basophilic granules are as large as the granules of eosinophils and evenly distributed in the cytoplasm. In certain species (e.g. the dog) they are assembled in a small compact group. The erythrocyte diameter is almost the same as that of the horse,

ox, and larger than that of sheep. Hematological values of domestic animals have been reviewed by Dukes [1952], Maximow and Bloom [1952] and Trautmann and Fiebiger [1947].

In the buffalo, the erythrocyte count is higher than in cattle and lower than in sheep and horse, while the leucocyte count is less than in cattle, horse and sheep. The study of the differential count shows that the percentage of lymphocytes, monocytes and eosinophils are higher in the buffalo than in sheep and horse and lower than in cattle. The neutrophils are lower than in sheep and horse but higher than in cattle. The basophils are almost of the same frequency (1 per cent) in all farm animals.

The specific gravity of the buffalo blood is slightly lower than that of the horse and higher than that of cattle and sheep. The pH number varies within narrow limits, it is within the normal range of pH of mammalian blood. The sedimentation rate in the buffalo is much higher than in cattle and lower than in horse, while the clotting time of buffalo blood is longer than in sheep, shorter than in horse and similar to that of cattle. A comparison between the hematological values of the Egyptian and Indian buffalo is shown in Table IV.

TABLE IV

Hematological values of Egyptian buffalo as compared with that of the Indian buffalo

Item	Unit	Egyptian buffalo	Indian buffalo
Red count	million/mm ³ .	6.8	6.1
Hemoglobin	gm./100 ml.	12.96	7.7
Hematocrit	Percentage	44.3	35.5
Plasma proteins	gm./100 ml. plasma	7.43	7.46
Sugars	mg./100 ml.	81.4	79.4
Author		Present experiment	Kehar and Murty [1951]

The hemoglobin content as well as the sugar level is higher in the buffalo than in all other farm animals. The plasma proteins and the non-protein-nitrogen are similar to that of cattle and higher than that of other farm animals. As far as the minerals are concerned, the buffalo blood is characterized by a relatively high content of phosphorus and a low content of calcium and sodium. Potassium is almost the same in all farm animals.

SUMMARY

Thirty healthy adult Egyptian buffalo-cows aged from three to ten years were available at the Animal Production Research Farm, Faculty of Agriculture, University of Cairo, Giza, Egypt. Cytological, physiological and chemical constants of their blood were studied.

1. In the buffalo, the blood corpuscles possessed the same staining affinity as in other mammals. The erythrocyte count was $6.8 \times 10^6/\text{mm.c.}$ while the leucocyte count was $6.7 \times 10/\text{mm.c.}$ In the leucocytic differential count the percentage of lymphocytes, neutrophils, monocytes, eosinophils and basophils were 51, 36, 8, 5 and <1 respectively.

2. The specific gravity of the buffalo blood was 1.058 gm./ml. The pH number was 7.45 the sedimentation rate after one hour was 6 mm. and the clotting time was 6.75 minutes. The hemoglobin content was 12.96 gm./100 ml. blood and the hematocrit was 44.3 per cent.

3. In buffalo the blood sugar was 81.4 mg./100 ml. while the non-protein-nitrogen ranged from 25—42 mg./100 ml. blood. The plasma proteins were 7.45 gm./100 ml. plasma while the sodium, potassium, calcium and phosphorus/100 ml. plasma were 415, 26, 10, and 28 respectively.

4. The comparative study of certain cytological, chemical and physiological features may be of academic significance to investigate the evolutionary trends of species and breeds.

ACKNOWLEDGMENT

The authors are thankful to Prof. A. L. Badreldin, Animal Production Department, Faculty of Agriculture, University of Cairo and Dr M. H. Maghrabi of the Animal Breeding Section, Ministry of Agriculture, Egypt, for providing facilities and help.

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ISOLATION OF *SALMONELLA-LITCHFIELD* FROM AN OUT-BREAK IN CHICKS IN THE INDIAN UNION

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(Received for publication on January 3, 1956)

IN spite of the frequency of paratyphoid fevers in man and the general importance of the Salmonella problem in public health, including meat and milk inspection, the animal Salmonella problem has been scarcely touched, the chief reason being the dearth of trained workers and the mass of general diseases that confronts the animal pathologist.* The authors of this statement, Shirlaw *et al.*, [1945] listed a few Salmonellae isolated in animals in India by previous workers, viz. *Sal. abortus equi* in horses, *Sal. gallinarum* in chickens, *Sal. enteritidis* in pigeons, *Sal. dublin* in calves and *Sal. typhi-murium* in hounds. Since the publication of this report, little has been added to our knowledge of the incidence of salmonella infections in animals in India probably due to the same reasons. Of late, due to the establishment of large government poultry farms as a means for increasing food production, the attention of animal pathologists has been drawn to this problem, mainly to prevent poultry mortality; their efforts, however, have been confined to organized farms. No attempts are made, however, to determine the incidence of salmonellae in the rural poultry population which is the main source of supply to the markets. The adult chickens in the villages are most likely to be carriers and reservoirs of these organisms, particularly due to their feeding habits which are essentially scavenging in manure dumps, cesspools, and waste lands around hutments. The single factor which keeps down the spread of these pathogens to man is the cooking of poultry-meat and eggs before consumption. The handling of these products, the use particularly by invalids, of eggs in the raw state and in bakery products, and the frequent presence of chickens within the homes of the villagers, are the public health risks which cannot be over-emphasized.

Salmonella typhi-murium was first isolated from a mouse epizootic in 1890 by Loeffler. It has since been reported in many animals and man. Kauffmann [1941] states that from surveys carried out in England, Germany and Denmark, *Sal. typhi-murium* was responsible for an average of 65 per cent of the cases of salmonellosis in man. Iyer and Rao [1950] reported an outbreak of the disease in India, in a chicken farm due to this organism. *Sal. anatum* in ducks was recorded by Rettger and Scoville [1920], and since then it is known to have caused the disease in poultry and man in many parts of the world. It was often the cause of serious mortality among ducks in the Army Development Farms in India in world war II [Rao,

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1946]. Dixit [1951-1952] isolated *Sal. anatum* in baby chicks in Bombay Province. Pande *et al.*, [1933] isolated a motile strain of *Salmonella* from baby chicks, which was subsequently typed as *Salmonella bovis moribificans* in England.

The author isolated three strains of *Salmonella* (other than *S. pullorum*) in 1952-53 from serious outbreaks, two in chickens and one in a rabbitry. All three were identified by preliminary biochemical and serological tests as *Sal. typhi-murium*, and were confirmed by Dr J. D. Blackland of the Weybridge Laboratory (*Annual Reports I.V.R.I.* 52-53). A fourth one was subsequently isolated from baby chicks, and was taken to Canada for identification and forms the subject of this report.

EXPERIMENTAL PROCEDURE

The organism was isolated from a large military poultry farm where it accounted for 50 per cent mortality in a lot of 3,000 hatchery chicks, ages ranging from 7 days to 4 weeks. The general symptoms observed were crowding of the chicks together under the hover, droopiness and diarrhoea. Over 100 autopsies conducted revealed no definite symptoms, except pallor of the internal organs and the skeletal muscles. Rapid whole-blood agglutination test of the laying flock with an "O" antigen, prepared from the specific organism isolated, failed to detect any carriers. The disease was, however, brought under control by dosing with sulphamezathine (a 16 per cent solution of the sodium salt) in drinking water, at a level 0.2 per cent sulphamezathine, for 6 days.

Cultures were regularly obtained from heart-blood and liver on agar slants, while the organism was isolated from the intestinal contents after enrichment in brilliant green and tetrathionate broth and subsequent sowing on MacConkey plates. The strain was maintained for a year on plain agar before final identification was carried out.

The organism was a Gram-negative, motile rod which possessed the morphological and cultural characters of the Enterobacteriaceae. Arabinose, dextrose, dulcitol, galactose, levulose, maltose, mannitol, mannose, rhamnose, soribitol, lactose and zylose were fermented promptly with the production of acid and gas. Acid and gas were produced in cellobiose after 7 days, and acid only was found in dextrin and glycerol in 7 and 14 days, respectively. Adonitol, inositol, inulin, lactose, raffinose, salicin and sucrose were not fermented. Indole was not formed and the cultures failed to utilize citrate, liquefy gelatin or decompose urea. The organism fermented d-tartrate, was Methyl Red positive and Voges-Proskauer negative.

Slide agglutination tests with *Salmonella* O sera showed the following results :

	Agglutination
Pool 1 (O factors 1,2,3,4,5,9,10,12,15,19,21,26,27)	—
2 (O factors 6,7,8,11,13,14,20,22,24)	+++++
3 (O factors 16,17,18,28,29,30)	—
4 (O factors 35,38,39,40,41,42)	—
With the sera of Pool 2 : factors 6,7	+++++
7	—
6,8	+++++
8	+++++
Others	—

The culture appeared to be predominantly in the second phase, reacting strongly in "1,2" and single factor "2" H antisera. Phase suppression was carried out with "1,2" absorbed H sera on swarm agar plates. Three transfers on suppression plates were necessary before the "1,2" phase could be suppressed and the phase 1 antigenic structure demonstrated. When tested with phase 1 antisera, strong agglutination was obtained only in "*l,v*", "*l,w*" and "*v*" antisera; no agglutination was observed with absorbed "*w*" antiserum. In tube tests, the organism agglutinated to titre in "*l,v*" and "*v*" sera, thus confirming the results of the slide tests. Therefore, its antigenic structure is 6,8; *l*, *v*-1,2, identified as *Sal. litchfield*.

DISCUSSION

Sal. litchfield was first isolated by Pomeroy from a turkey poult in 1940 [Edwards and Bruner 1940] and later from human sources, but has not been previously reported in chickens. The occurrence of this pathogen in chickens further confirms the presently accepted view of several workers, including that of Seligmann *et al.*, [1943], that *Salmonellae* are not host-specific and that every one of the three hundred odd ones is potentially capable of producing groups of clinical processes, like gastro-enteritis, enteric fever, meningitis, etc., and that animals and birds may act as reservoirs. It is generally conceded today that animals, particularly poultry, are the principal reservoirs of most of the *Salmonellae*, thus emphasizing the great need for controlling the disease in animals, as a most important public health measure.

SUMMARY

A *Salmonella* organism isolated from baby chicks, which caused a mortality of 50 per cent in a large military poultry farm in India, has been identified as *Sal. litchfield* (6,8; *l*, *v*-1, 2). Experimentally, the organism was found to be pathogenic for young chicks, while the adults became carriers. Sulphamezathine in drinking water controlled the disease effectively. The need for organized efforts to control animal reservoirs of *Salmonella* as a public health measure is stressed.

ACKNOWLEDGMENT

The author expresses his indebtedness to the Government of Canada for sponsoring his training under the Colombo Plan. He acknowledges with thanks the advice and expert guidance he received in the technique of the preparation of the various sera required in general for typing of *Salmonella* from Dr E. T. Bynoe, Chief, Bacteriological Laboratory Services, and Dr W. R. Bailey, Bacteriologist-in-Charge of the National *Salmonella* and *Shigella* Typing and Reference Centre, Laboratory of Hygiene, Department of National Health and Welfare, Canada. Thanks are also due to Miss R. Laidley for her help.

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THE EFFECT OF AUREOMYCIN AND VITAMIN B₁₂ ON THE GROWTH RATE OF CHICKS

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(Received for publication on February 17, 1956)

MANY investigators have reported increased growth rate and feed efficiency when chicks are fed rations fortified with aureomycin and vitamin B₁₂ [Biely *et al.*, 1952, Machlin *et al.*, 1952 and Sizemore *et al.*, 1953]. Groschke and Evans [1950] reported that aureomycin exerted a definite stimulating effect upon growth when fed to chicks. Heuser and Norris [1952] compared a number of antibiotics when fed to chicks and reported variability in response to the same antibiotics in different experiments. They obtained the greatest response with chicks of four weeks of age. This is in agreement with Scott and Glista [1950] but at variance with Berg *et al.*, [1950]. Davis and Briggs [1951] in studying the effects of aureomycin, penicillin, bacitracin and terramycin report that growth stimulation resulted in most cases and that antibiotics improved feed efficiency. Saxena *et al.*, [1952] fed penicillin at three levels of protein, 21, 18, 15 per cent respectively. They reported significant and consistent response in growth to penicillin at all levels of protein tested. Biely and March [1951] report no response to antibiotics in rations containing above normal amounts of vitamins but in rations low in riboflavin, folic acid and or nicotinic acid, antibiotics gave significant growth increases. Scott *et al.*, [1952] in studying the influence of aureomycin on the protein requirements of chicks found the improvement in protein efficiency no greater than the improvement in feed efficiency, so there was no protein sparing action from the antibiotic. They also reported that chicks on a 20 per cent protein ration gave no response to aureomycin. Bose *et al.*, [1955] fed Fortracin-6 (bacitracin and vitamin B₁₂) to chicks of eight weeks of age and obtained increased growth from the antibiotic.

Since most of the work reported on the use of antibiotics for chicks has been done outside India and with more complete diets than are generally available here, it was considered desirable to investigate the effects of aureomycin and vitamin B₁₂ when fed to chicks on a common ration.

EXPERIMENTAL

White Leghorn chicks obtained from Government Farm, Mathura were used in this study. Three-day-old chicks were randomly distributed into eight groups of eleven chicks each and randomly assigned to pens in wire cages. The groups were:

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rotated each week to eliminate possible effect of position. Feed and water were supplied *ad libitum*. The feed remaining each day was weighed back and not offered again. Records of weekly weights, mortality and feed consumption were kept.

TABLE I
Composition of basal diet

Basal diet	parts
Ground yellow maize	50
Wheat bran	10
Groundnut cake	30
Fishmeal	5
Steamed bonemeal	2
Limestone	1
Lucerne leaves	1
Salt	$\frac{1}{2}$
Sharkliver oil	$\frac{1}{2}$

The basal diet shown in Table I contained approximately 21 per cent protein (6.25 \times Nitrogen). The basal diet was fed to four groups of 11 chicks each. The other four groups of 11 chicks each received the basal diet plus 9 grams aureomycin and 9 milligrams vitamin B₁₂ per ton of feed (Aurofac at rate of 5 lb. per ton).

The experiment was originally planned to continue for an eight-week period but due to a serious outbreak of fowl pox during the early part of the seventh week, resulting in a number of deaths in birds, it became necessary to summarize the results at the end of six weeks.

RESULTS AND DISCUSSION

A summary of the data obtained on growth and gain per lb. of feed fed, is shown in Table II.

TABLE II
Effect of aureomycin and vitamin B₁₂ on the growth rate and feed consumed by White Leghorn chicks up to six weeks of age

Diets	No. of Chicks	Average weight per chick (grams)						Gain per lb. feed consumed (gm.)
		Start	2 weeks	3 weeks	4 weeks	5 weeks	6 weeks	
Basic only	44	47.6	74.5	94.0	125.3	164.3	211.1	67.2
Basic aureomycin and B ₁₂	44	47.2	81.5	108.4	147.8	188.4	242.1	71.4
Least significant mean difference	—	—	10.7a	13.8b	17.6a	25.5a	28.6a	a-p.05 b-p.02.

The addition of aureomycin and vitamin B₁₂ gave a significant increase in growth of chicks from three to six weeks of age. The response from three days to two weeks of age was evident but not quite significant statistically at the 5 per cent level of probability.

Growth rates were markedly lower than those reported by many other workers. Bose *et al.*, [1955] report an average weight of 243 gm. for the control and 290 gm. for the treated chicks at six weeks of age. Saxena *et al.*, [1953] report 340 gm. for untreated chicks and 372 gm. for treated chicks at four weeks of age. This may be due in part to extremely unfavourable temperature during the experiment as it was conducted during April and May. The official maximum temperature at Allahabad was as much as 114°F. during the experimental period. Results also indicate that there is wide variation in growth rate between individual chicks with a range from 89.2 gm. for the smallest to 521.3 gm. for the largest chick. This suggests need for more rigid selection for rate of growth and uniformity in breeding stock.

SUMMARY

1. Aureomycin and vitamin B₁₂ gave a significant and consistent growth response when fed to chicks from two to six weeks of age. Response to two weeks was indicated but the difference was not great enough to be significant at the 5 per cent level of probability.
2. Aureomycin and vitamin B₁₂ reduced the amount of feed per unit gain, however, the difference was not significant.
3. The wide variation in growth rate between chicks indicates a lack of uniformity in the inherited growth rate stimulus in these chicks.

ACKNOWLEDGMENT

The authors gratefully acknowledge the kindness of Lederle Laboratories (India) Ltd., Bombay, in furnishing the Aureofac (aureomycin and Vitamin B₁₂) used in this experiment.

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ABSTRACTS

The control and treatment of certain forms of mastitis. EDWARDS, S. J. (1954), *Vet. Rec.*, 66. 37-40

WHILE reviewing the incidence of mastitis in various herds in different parts of England the author attributes the reduction in general incidence of infection to better conditions of dairy hygiene and the use of therapeutics. The success achieved in the control of infection was found to be intimately connected with the milking technique employed in a herd, the less the manipulation of teats during milking the better the success in the control. According to Edwards about 90 per cent of cows infected with *Str. agalactiae* respond well to the treatment of two doses of 100,000 units of penicillin injected at an interval of 48 to 96 hours. The cows which retain infection even after this treatment may be living under defective hygienic conditions and usually have teat sores. He suggests the following measures for controlling *Strept. agalactiae* infection:

1. Conduct the bacteriological examination of composite milk samples of each cow.
2. Treat the infected cows and dry cows with two injections of 100,000 units penicillin in each quarter at three-day interval. Milkers should apply some antiseptic cream on their hands before milking, for a week.
3. Stop hand stripping and use separate sterile cloth for washing the udder of each cow with a suitable disinfectant before milking.
4. Retest the herd and retreat all infected cows.
5. A further test after three months should be done and if infection disappears, washing with disinfectants should be discontinued.
6. Thereafter, repeat the test at six months interval. Obstinate cases showing sore teats should be dressed and re-treated. Those found infected still, should be separated.

Edwards recommends the use of 100,000 units of penicillin injected four times at 48 hours intervals, for the treatment of staphylococcal infection and feels that maintaining cows free from infection was a difficult proposition and could be achieved by adopting a policy of elimination on the lines practised for *Str. agalactiae*. [M.S.S.]

A pathogenic pleuropneumonia-like organism from goats. D. R. CORDY, H. E. ADLER AND R. YAMAMOTO (1955). *Corn. Vet.* XLV. 50-68

AN outbreak in a herd of French Alpine goats caused by a pleuropneumonia-like organism (PPLO) and characterised mainly by fever (103° - 106° F) and arthritis is described. Course of the disease varied from 24 hours to 5 weeks, acute type being met with mostly in kids.

While experimental transmission of infection to healthy kids, sheep, lambs and pigs was possible, the disease could not be produced in guinea-pigs, mice and calves. In experimental cases the period of inoculation varied from within 24 hours by I/V and I/P routes of infection to 108 hours by conjunctival instillation; and the course lasted for 2 to 11.5 days.

Apart from the most characteristic fibrinopurulent arthritis with variably enlarged articulations (mainly affecting the carpal joints), hyperaemia and degenerative changes, leading to necrotic foci in protected cases, in lymph glands, liver, spleen and kidneys, accompanied by neutrophilic infiltration in these situations and enlargement in the case of lymph glands and spleen, were conspicuous pathological features. None of the affected animals, except for two experimental lambs, showed pneumonia; the histopathological evidence of hyperaemia and alveolar oedema found in the lungs of some cases could probably be ascribed to a failing heart. Udders of the three lactating females, although reddened, did not present any clinical manifestations of mastitis or alteration in the appearance of their secretion; microscopic change, however, consisted of hyperaemia and some oedema accompanied, in two cases, by neutrophilic invasion.

PPLO could be recovered in cultures on serum agar from affected joints and spleen. Culturally, the organism almost resembled the contagious caprine pleuropneumonia organism. Antigen prepared from the PPLO isolated was agglutinated by homologous serum (1:640) and by goat pleuropneumonia serum (1:10) but not by agalactia serum. Coliform contaminants were encountered in the lungs and livers of long standing cases of the disease.

Inoculation of 0.2 ml. of a 5th culture passage of this PPLO in six day old embryonating eggs via the chorio-allantoic or yolk sac killed the embryos in three days.

None of the antibiotics tried (penicillin, streptomycin, terramycin and aureomycin) gave promise of being a useful remedy.

The authors consider this outbreak to be different from pleuropneumonia or agalactia on grounds of clinical and serological observations as also due to lack of host specificity.

[G. S.]

The effects of age upon calcium utilisation and maintenance requirements in the bovine: HANSARD, S. L., COMAR, C. L. and PLUMLEE, M.P. (1954). *J. Anim. Sci.* **13**, 25-36

IN the present study, the authors have made use of concepts and experimental methods developed by them recently through the application of the radioactive tracer technique. These methods enable separate computation of the different components that constitute faecal calcium output, viz. unabsorbed portion from the feed, the fraction which has been absorbed but re-excreted, and the quantity lost from the body stores. The conventional balance experiments are utterly inadequate in this respect.

The investigation involved concurrent chemical and radioisotope balance experiments conducted on 34 cattle belonging to seven different age groups (10 days to 190 months), after the administration of a single dose of radiocalcium. In these experiments, positive calcium balance was maintained in the young animals, but the mature (36-73 months) animals were in slightly negative balance. It was significant that in the case of old cattle (144-190 months) the calcium excretion greatly exceeded the intake, even when the feed was fortified with calcium phosphate.

The computed values for endogenous calcium excretion per kg. body weight remained practically constant from one month of age to maturity (1.44-1.80 mg.). However, the level was lower in 10 days old animals and higher in aged cattle. The true digestibility figures were: 98 per cent at 10 and 30 days, 34 per cent in adults and 22 per cent in aged cows. The maintenance requirements per 100 lb. body weight were estimated at 0.55 gm. at 10 days about 2.0 gm. from 6 months to maturity and 4.5 gm. for aged cattle.

The paper includes a valuable discussion on faecal calcium partition and its significance. [R.M.]

The effect of environmental temperature and humidity on the respiration rate and the frequency of the heart beat of Ayrshire calves: W. R. BEAKLEY and J. D. FINDLAY (1955). *J. Agric. Sci.* **45**, 452-468

THE authors recorded the respiratory and heart rates of three four-month-old Ayrshire bull calves in individual six-hour daily exposures to 15, 20, 25, 30, 35 and 40°C. dry bulb temperatures at 17 mg./l. absolute humidity and at 7 mg./l. saturation deficit at temperature 30, 35 and 40°C. The schedule of experiments on each animal lasted 45 days consisting of five replications of these 9 environmental conditions. The experiment was conducted in a temperature controlled laboratory, the respiration rates and heart rates of three experimental and three control animals were measured in a holding room before the experimental animals of each pair were transferred to the hot room.

The results showed that the frequency of respiration and heart rate of all experimental animals increased with increasing environmental temperature above 20°C and with increasing humidity above 30°C.

Respiration rate rose to a maximum value which occurred in the second and third hour of exposure. The magnitude of this maximum value varied linearly with environmental temperature by 4.9 respiration/min/°C. The variations of the respiration rate at the last hour of exposure with environmental temperature was non-linear whereas after the second hour of exposure to environmental temperature above 25°C, the heart rates of the experimental animals declined with the increasing time of exposure to a given environmental temperature.

The general behaviour of respiration rate at high humidity at 30 and 35°C was similar to that at low humidity.

The effect of change in humidity at 30°C on the heart rate was not significant but at 35°C and high humidity, the heart rates of all animals increased with increasing time of exposure.

High humidity at 40°C increased panting considerably and caused profuse salivation, the heart rate also increased rapidly to a very high level.

The authors concluded that though various workers have attempted to fit empirical equations to describe the effect of environmental temperature on respiration rate but this relation might be unreliable and of little value if it was used as an index to measure the animal's aptitude to withstand the thermal stress. The variable nature of heart rate with change of temperature and humidity and with other factors, namely feeds and presence of observer make it unreliable index of heart tolerance in young bovine.

[D. N. M.]

The incidence and pathological significance of nematodes in the central nervous system ; J.F.A. SPRENT (1955). *Parasitology*, 45. No. 1&2. pp. 21-40

THE paper reviews the available literature on the incidence and pathological significance of nematodes in the central nervous system. It has been observed that a large number of nematodes invade the central nervous system and cause a variety of nervous symptoms. Living specimens of different nematodes have been recovered from the meningeal spaces and tissues of the brain and spinal cord by various workers. These nematodes belong to the orders of:

Ascaridoidea, Filarioidea, Trichuroidea, Strongyloidea, Metastrongyloidea, Rhabditoides, and Diectophymatidae.

The pathological effect caused by these nematodes vary to a great extent depending upon the size, mobility and the activity of the parasite. The pathological changes observed are haemorrhagic, degenerative or proliferative. These are all the direct effects of nematodes on the central nervous system and are mainly due to the traumatic effect of the parasite on the central nervous system depending upon its size.

Several parasites and their involvement in causing the pathological changes have been mentioned. It has been stated that *Setaria* spp. (Filariodea), in cattle and horses, cause the disease known as "Kumree" wherein the parasites cause softening and congestion of the spinal cord. Similarly lumbar paralysis, in goats, has been attributed to the invasion of central nervous system by the larvae of *Setaria digitata*.

The symptoms vary according to the degree of invasion of the parasite on the central nervous system. Nervous symptoms have also been described in somatic nematode infections. But no explanation as to the occurrence of these symptoms can be given; one school of thought, however, considers that these symptoms are probably, of allergic origin.

This argument is based on the evidence that certain toxins are elaborated by some parasites such as *Trichinella*. It has also been experimentally proved that infection of the larvae of *Ascaris suum* induces a state of hypersensitivity, with allergic symptoms. The injection of ascaris extracts in animals already sensitised, caused certain changes in the central nervous system. So, in all probability, these changes in the nervous system may be due to the allergic reactions brought about by ascaris antigen.

It has been proved that these nematodes also transport viruses to the different parts of the central nervous system and thus act as carriers of virus. It has been observed that *Ascaris suum* transmits a virus which causes infectious paralysis in pigs. However, there is no possibility of poliomyelitis being transmitted by these nematodes, as observed by many workers. It is also doubtful whether there is any possibility of *Setaria digitata* transmitting the virus of Japanese *B. encephalitis*. [V.V.S.]

The effect of sodium sulphaquinoxaline and sodium sulphamezathine in interrupted schedules of treatment on the development of *Eimeria tenella* : DAVIES, S. F. M. and KENDALL, S. B. (1954). *J. Comp. Path.* Vol. 64, No. 2., 87-93

DAVIES AND KENDALL review literature accounting for irregularities in results obtained in the treatment of caecal coccidiosis with known fully-effective sulpha drugs. Briefly, it is ascribed partly to varying susceptibility of various developmental stages of the organism and partly to the irregular rate of development of individual parasites.

In this paper they record results of their experiments on the treatment of caecal coccidiosis in experimentally heavily infected chicks with sodium salts of sulphaquinoxaline (SQX) in 0.043 per cent and 0.0645 per cent concentrations, and sulphamezathine (SMT) in 0.2 per cent concentration in drinking water. Two different schedules of treatment were adopted, namely 2-3-2-3-2 schedule, i.e., three two-day periods of treatment with intervals of three days without treatment; 3-2-3 schedule, i.e., two three-day periods of treatment with a two-day interval without treatment. All groups of chicks received infection on the same day while treatment was given to successive groups on successive days, starting treatment two days before the infection for the first group under each section, second group receiving treatment one day before the infection and so on. Mortality rate was the criterion kept for evaluating results.

Under both schedules of treatment 0.0645 per cent concentration of SQX was more effective than 0.043 per cent. 2-3-2-3-2 schedule could not completely control infection, the lowest mortality rate being 70 and 45 per cent with SQX (0.043 per cent and 0.0645 per cent concentrations respectively) and 20 per cent with SMT treatment when medication was started 48 hours after infection. On the other hand, 3-2-3 schedule completely controlled infection with both the drugs when medication was started 48 and 24 hours after infection with SMT and SQX (0.0645 per cent) respectively. 0.043 per cent concentration of SQX was less efficacious as at best it could reduce mortality to 40 per cent with a treatment started 48 hours after the infection.

The authors conclude that any form of interrupted therapy, including withdrawal of drug for a period exceeding two days, is likely to be less successful, and 3-2-3 schedule of interrupted therapy assures better control of the disease than the 2-3-2-3-2 schedule. [B. S. G.]

Antibiotics and surface active agents in chick nutrition : B. E. MARCH, M. BURDELL and JACOB BIELY (1954). *Poult. Sci.* **33**, 300

THE experiments conducted by the authors to investigate the effect of two surface active agents Tween-80 (Polyoxyethylene) sorbitan monooleate and Santomerse-80 (an alkylaryl sulfonate) on the growth of chicks, indicated considerable differences in the growth stimulating properties of these agents. The surface active agents and/or antibiotics were incorporated in diets of different composition to examine the response of chicks to these substances.

The inclusion of Tween-80 to a chick starting ration improved the growth response and feed efficiency. In a second experiment, the addition of antibiotics as well as Santomerse-80 increased the growth rate of chicks fed folic acid deficient diet, but the addition of Tween-80 did not.

The combination of Santomerse-80 and penicillin produced a slightly faster rate of growth than that of penicillin alone, whereas no additional response was recorded beyond that observed with antibiotics, when Tween-80 was fed in conjunction with the antibiotics.

The addition of herring oil to a chick starting ration supplemented with Santomerse-80, alone or in combination with penicillin, depressed the growth stimulating effect of the surface active agent, that was observed when it was supplemented to the above ration with no added oil, whereas penicillin alone increased the growth of chicks irrespective of the oil content of the ration fed.

The inclusion of Santomerse-80 and/or aureomycin to three different diets, had an insignificant effect on growth rate and feed utilization in either the basal rations or the rations supplemented with oil.

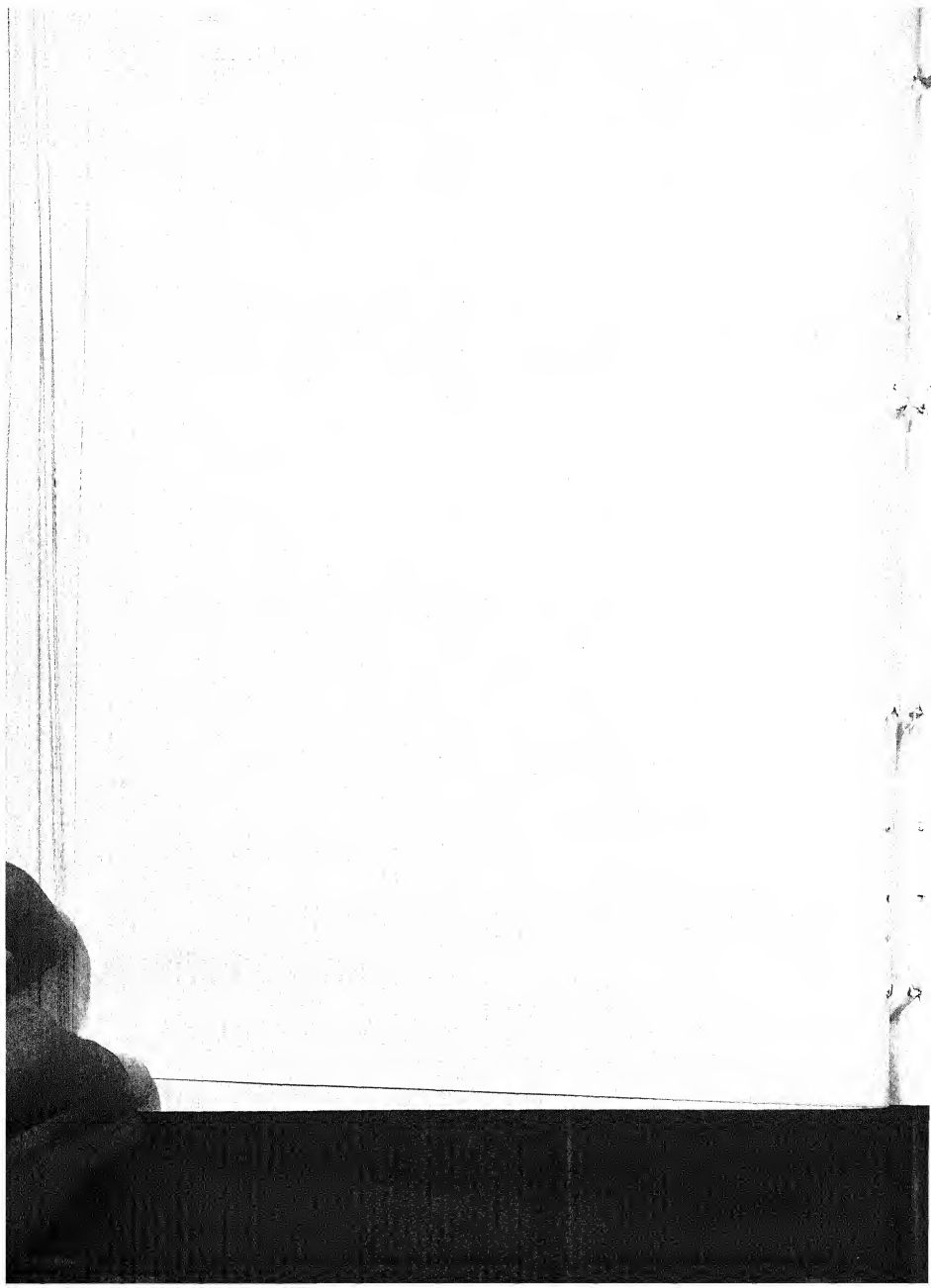
The differences in the growth stimulating properties of these surface active agents are difficult to explain. However, it is evident that the differences in the composition of the ration may to some extent account for the variations in the

response of these surface active agents, which was apparent only when the chicks were four weeks old. The response to a surface active agent was in no instance better than the one obtained by supplementing an antibiotics to a similar diet. [V. N. M.]

Über den oestrogengehalt verschiedener Futter gräser (Oestrogen content of different fodder grasses) : G. SCHOPF, H. KLETTE and G. RENNER (1955). *Dtsch. tierärztl. Wschr. Beilage : Fortpflanzung, Zucht Hygiene und Haustierbesamung* 5 (9), 103-107

FOURTEEN kinds of meadow grasses were examined for oestrogen content. They were, (1) *Festuca pratensis*, (2) *Poa pratensis*, (3) *Avena flavescens*, (4) *Alopecurus pratensis*, (5) *Poa fertiles* (Serotina), (6) *Agrostis alba*, (7) *Avena elatior*, (8) *Phleum pratense*, (9) *Dactylis glomerata*, (10) *Lolium perenne*, (11) a German pasture grass (variety : odenwälder), (12) a German pasture grass (variety : N. F. G.), (13) *Festuca rubra*, (14) *Lolium italicum* (multiflorum). The respective amounts of oestrogenic substances in terms of mouse units per kilogram found in these 14 grasses were approximately, 1200, 500, 3400, 50, 800, 1250, 6000, 700, 1000, 700, 7000, 5600, 13000 and 12300. With the exception of two grasses, all were cut 1-3 weeks before flowering.

Plant oestrogens were found to be more efficacious when administered orally than when injected, showing that probably they were different from oestrogens of mammalian origin. The authors suggest that plant oestrogens play an important part in the metabolism of animals. If for example, a maximum limit of oestrogens in food is passed, sexual troubles may follow. Similar disturbance in sexual cycle may attend the presence of too small quantities of these in food. [S. S. P.]



REVIEW

Züchtung, Ernährung und Haltung der landwirtschaftlichen Haustiere Allgemeiner Teil. By SCHMIDT, J., PATOW, C. V. AND KLIESCH, J. (1956E) (Breeding, feeding and keeping of farm animals—General part) Berlin ; Verlag Paul Parey. viii 366 pp. 125 Figs. Price : DM. 28

This is the seventh revised edition of the first volume of a two-volume standard German text-book on animal breeding, feeding and keeping of farm animals. The volume discusses the general principles involved in animal husbandry. The subject matter is divided into six major headings ; (a) German cattle position, fodder resources and production, (b) Concept of "breeding" and the material of breeders, (c) Reproduction and heredity as basis for breeding, (d) Breeding procedures, (e) Measures for promoting animal breeding and (f) Feeding and keeping of livestock of economic importance. The subject under heading (a) covering 13 pages may be taken as introduction. The portion devoted to breeding covers about 200 pages and the rest of the pages deal with nutrition and animal keeping. There is an index also.

After reviewing the cattle position in Germany today in comparison to what it was prior to war and earlier, with reference to livestock and production statistics, the reader is introduced to the subject of breeding procedures, by first discussing the place and time of origin of the domesticated animals, followed by a formal presentation of the principles of reproduction and genetics explained through examples taken exclusively from animal material. In considering the breeding procedures, the place and aim of breeding, the relative importance of breeding and type, pure breeding, cross breeding and inbreeding are first discussed ; then follows a chapter on selection : selection according to breed and species, according to conformation and performance, according to constitution, pedigree and progeny ; how selection can improve health, resistance, longevity, fertility, development, production and thriftiness. The portion dealing with constitution would be of special interest to Indian readers. Production covers milk, work and wool and combination of more than one economic trait. Among measures aiding breeding operations, the role of co-operatives and breeders associations are described.

The chapters on nutrition follow the formal pattern of presentation. After describing the various feeding stuffs, the wastes from the different industrial establishments, the nutritive value and requirements of various classes and kinds of animals are given. Detailed ration schedule tables for feeding work horses, brood mares, foals, milch cows, 1-2 year old heifers, 1 year old calves, suckling calves, breed sows, suckling pigs, market pigs and poultry are given. This is a special feature of the book which combines the sound exposition of the theoretical principles with the practical suggestions that are useful for both the students and the practical animal husbandrymen.

In the chapters on keeping livestock, after discussing the basic principles, specific suggestions, illustrated by neat diagrams and photographs of buildings and sheds to house the different kinds of livestock are presented.

The book has excellent getup. Though the practical suggestions are based chiefly on conditions met with in Germany, the book as a whole should prove useful to Indian students also. It is a pity that a book of this type that gives at one place all relevant information on theoretical and practical aspects of animal husbandry and breeding is yet to be written in India, for use of Indian students of the subject.

(S. S. P)

A NEW SIRE INDEX FOR MILK PRODUCTION

By K. S. KRISHNAN, Indian Council of Agricultural Research, New Delhi

(Received for publication on April 3, 1956)

AN important aspect of the breeding programmes for dairy cattle is the evaluation of the breeding worth of the different bulls. Two methods are in common use for this purpose. One is the daughter average index which is the simple average of the milk yield of all daughters of a sire. The other is the commercial Mount Hope Index, also known as the Intermediate Index, obtained as :

$$I = 2\bar{D} - \bar{M}$$

where \bar{D} and \bar{M} are the average milk yields of daughters of the sire and his mates (mothers of daughters) respectively. Both these methods, however, suffer from certain shortcomings.

Any method of sire evaluation is likely to be affected by the culling of female calves and heifers. No satisfactory procedure is available for overcoming this defect in the estimation of the sire index. Retention of all female progenies till the completion of their first lactation, except for reasons of disease or confirmed infertility, is, therefore, essential for proper sire evaluation. Apart from this common limitation, the simple daughter average index does not take into account the possible assortive matings resulting in unequal average production levels of the dams sired by different bulls. One limitation of the intermediate index is that it overcorrects for the differential level of production of dams mated to different sires, that is, is the set of cows mated to a sire is inferior to the average, the index overestimates the sire's breeding worth, whereas if the dams are above average, the index underestimates its worth. Secondly, the intermediate index has a high sampling error with the consequence that many a times it fails to discriminate between even the best and the worst bulls among about a dozen bulls that may be used on a herd.

For the last few years extensive studies on breeding data for dairy cattle herds maintained at different Government farms have been undertaken by the Statistical Wing of the Indian Council of Agricultural Research. An important aspect of the analysis has been the examination of the relative merits of the sires used. In the

course of this work the above limitation of the two common-sire indices became increasingly clear and this led to the development of a new index which has been found to be superior to both. This new index is described in the present article and the method of calculating it is explained. The superiority of the new index over the other two is also illustrated by comparing the three indices in respect of 69 sires from six herds.

The new index

The proposed index is obtained from the formula :

$$S = \bar{D} - b(\bar{M} - A)$$

where \bar{D} is the average for the daughters of the sire, \bar{M} is the average for the dams of these daughters, b is the intra sire regression of the daughters' performance on that of its dam, and A is the herd average.

This index is the ordinary regression estimate familiar in sampling theory, wherein dam's performance is treated as the auxiliary variable. It may be termed as the corrected daughter average index or corrected index for short.

The superiority of the corrected index over other two is partly due to its lower sampling error and to the more appropriate allowance it makes for the inequality in the production levels of the dams mated to different bulls. From theoretical considerations it has been deduced that for a heritability of 50 per cent or less—and actual analysis of breeding data shows that for most of the quantitative characters of interest this is true—the corrected index will on an average be more than four times as efficient as the intermediate index, the standard error for the former being less than one half of the latter. In other words, about four times as many daughter-dam pairs of records will be necessary for estimating the worth of the sire with a given precision if the intermediate index is used, as are required with the corrected daughter average index. The corrected index will also be more precise than the simple daughter average index, the extent of superiority depending on the value of the heritability coefficient, provided that the number of daughter-dam pairs is not too few. The derivation of these results is given in the Appendix I.

The appropriateness of the correction made for the unequal production levels of dams mated to different bulls, made in the corrected index can be seen from the following considerations.

The phenotypic superiority of a selected group of individuals from a lot should be considered as made up of two parts; one part ascribable to better genetic make-up and the other to environment. The fraction due to better genetic make-up is

equal to the heritability coefficient for the herd. One half of the additively genetic superiority or otherwise of each parent over the average of the whole lot can be expected on an average, to be transmitted to the offspring. Thus if a dam is selected on the basis of its milk yield which is higher than the herd average by x lb., and is mated to a bull of average merit, the resulting progeny, if daughter, may be expected to yield $\frac{h^2}{2} x$ lb. more milk than the herd average, where h^2 is the heritability coefficient. This implies that, even under the assumption of equal contribution from both the parents, the appropriate correction to be applied for the daughters' average in order to eliminate the influence of differential production levels of the dams mated to different bulls is $\frac{h^2}{2}$ times the average phenotypic superiority of the dams mated to the bull concerned, over the herd average. This quantity should be algebraically subtracted from the daughters' average, i.e. numerically subtracted or added according as the average production of the dams mated to the bull concerned is higher or lower than the herd average.

It has been shown by Lush [1945] and others that twice the intra-sire regression of daughter's yield on that of its dam usually provides the best estimate of the heritability coefficient for a herd. This has been seen to be the case in respect of the Indian herds so far studied. The intra-sire regression accordingly provides the best estimate for the factor $\frac{h^2}{2}$ in the correction term. Using this estimate the correction may be seen to be the one given in the formula for S given earlier.

Computational procedure

The computation of the new index from actual data will be illustrated with the help of the records pertaining to the Haryana herd maintained at the Government Cattle Farm, Hissar. The first lactation yields over 300 days or less, measured in units of 10 lb., are analysed. These yields in respect of each of the 10 sires tested are given in Table I.

The quantities that are required to be calculated are (a) the herd average, (b) the intra-sire regression coefficient, (c) the corrected index and (d) the standard error of the index.

The herd average required for the calculation of the corrected index is obtained as the average of the dam's yields without repeating the dams having more than one daughter. This average worked out to 130.8 units in the present case. The average for the herd will be taken as 1300 lb. in the nearest round figure.

The steps in the calculation of intra-sire regression are shown in columns (3) to (13) in Table II. As an illustration, the procedure for obtaining these figures

TABLE I

First lactation yields (in 10 lb. in 300 days or less) of the dams mated to different sires and their daughters
(Hariana herd, Government Cattle Farm, Hissar)

Sire I		Sire II		Sire III		Sire IV		Sire V		Sire VI		Sire VII		Sire VIII		Sire IX		Sire X	
Dam's yield	Daughter's yield	Dam's yield	Daughter's yield	Dam's yield	Daughter's yield	Dam's yield	Daughter's yield	Dam's yield	Daughter's yield	Dam's yield	Daughter's yield	Dam's yield	Daughter's yield	Dam's yield	Daughter's yield	Dam's yield	Daughter's yield	Dam's yield	Daughter's yield
176	184	127	121	108	231	200	141	68	93	186	129	235	202	43	128	47	123	94	114
222	118	231	142	177	219	108	82	74	90	67	135	23	77	168	161	182	92	188	116
222	174	207	196	177	135	91	156	87	151	208	283	73	117	168	107	229	220	188	177
82	136	109	139	228	211	107	158	232	188	208	160	73	125	219	230	82	60	87	166
32	66	154	85	105	119	179	86	141	164	68	190	298	227	219	139	62	172	54	71
66	110	154	162	204	190	57	152	141	171	73	151	29	93	238	272	187	202	..	..
66	131	154	84	204	199	56	176	123	121	25	131	..	..	161	130	187	223	..	..
201	194	142	74	204	120	164	134	50	168	..	..	..	..	..	..	19	178	..	..
..	..	..	..	203	176	78	79	..	..	..	..	..	..	..	..	209	84	..	..
..	..	..	..	203	43	..	..	..	..	..	..	..	..	..	..	88	135	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	273	142	..	..

TABLE II
Calculation of corrected daughter average indices and their standard errors (10 lb. unit)
(Hariana herd, Government Cattle Farm, Hissar)

Sire No.	Daughter dam pairs	Total for dams	Total for daughters	Sum of squares for dams			Sum of squares for daughters			Sum of products		
				Crude	C.T.	Corrected	Crude	C.T.	Corrected	Crude	C.T.	Corrected
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
I	8	1087	1063	186405	142311	44064	151005	141240	10550	156572	141778	14794
II	8	1273	1003	215332	294160	11372	138542	123751	12792	163374	160229	5145
III	10	1313	1673	344597	323697	18900	315015	279883	36022	299742	308315	—3573
IV	9	1040	1214	142800	120178	22022	177478	163755	13723	138410	140284	—1374
V	8	910	1150	126884	104832	24002	173742	163312	8430	138761	131675	8986
VI	7	885	1202	136191	96904	36387	223356	206401	10955	153942	143381	10861
VII	6	703	841	139167	82563	56739	139225	117880	18846	130646	98537	32009
VIII	7	1216	1167	236784	211236	25648	216859	184556	22303	217005	202725	14250
IX	11	1515	1641	251695	208657	73038	274619	244807	23612	237678	225010	11668
X	5	501	644	73709	62944	10765	90373	82947	7481	75226	72237	2900
Total	79	10944	11598	1685764	1565037	320727	1399029	1723548	176472	1711256	1630191	94005

TABLE II—contd.

Calculation of corrected daughter average indices and their standard errors (10 lb. unit)
(Hariana herd, Government Cattle Farm, Hissar)

Sire No.	Av. for dams (37-5)	'Dam's Av.'—Herd Av. (14)—130	(15) × b	Av. for daughters (57-6)	Corrected Indexes (17) — (16)	(7) × 1 ^a	(13) × 2b	Residual S.S. (10) + (19) — (20)	n(n-1)	Variance of Index (21) + (22)	S. E. of Index $\sqrt{\frac{1}{2n}}$
	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
I	133.4	+8.4	+1.0	125.0	131.9	2793	8975	5774	56	108	10.1
II	139.8	+29.8	+8.7	125.4	116.7	978	3613	10722	56	192	13.9
III	131.3	+51.3	+15.0	167.3	152.3	1365	—2008	39456	90	439	21.0
IV	115.6	—14.4	—4.2	134.09	130.1	1946	—1099	16768	72	233	15.3
V	114.5	—15.5	—4.5	143.8	148.3	2085	4743	5732	56	103	10.1
VI	119.3	—10.7	—3.1	171.7	174.8	3147	6195	13907	42	331	18.2
VII	117.2	—12.8	—3.8	140.2	144.0	4556	15776	4455	30	143	12.2
VIII	173.7	+43.7	+15.8	166.7	159.9	2108	3377	16124	42	384	20.0
IX	187.7	+7.7	+2.2	140.2	147.0	6253	6544	29251	110	266	16.3
X	112.2	—17.8	—5.2	128.8	134.0	926	1742	6615	20	331	18.2

for one bull, viz. Sire I, is explained, below :

Total for dams mated, repeating each dam's record as many times as the number of daughters from the same sire

$$=176+222+222+82+32+66+66+201 \\ =1067 \dots\dots\dots (\text{Col. 3})$$

Total for daughters

$$=134+118+174+136+66+110+131+194 \\ =1063 \dots\dots\dots (\text{Col. 4})$$

Crude sum of squares for dams, repeating each dam's record

$$=(176)^2+(222)^2+(222)^2+(82)^2+(32)^2+(66)^2+(66)^2+(201)^2 \\ =186405 \dots\dots\dots (\text{Col. 5})$$

Correction term for sum of squares for dams

$$= \frac{(\text{Total for dams})^2}{\text{Number of pairs}} = \frac{(1067)^2}{8} \\ =142311 \dots\dots\dots (\text{Col. 6})$$

Corrected sum of squares for dams

$$=\text{Crude S.S.} - \text{Correction term} \\ =186405 - 142311 \\ =44094 \dots\dots\dots (\text{Col. 7})$$

The corrected sum of squares for daughters is obtained in the same manner:
Crude sum of squares for daughters

$$=(134)^2+(118)^2+(174)^2+(136)^2+(66)^2+(110)^2+(131)^2+(194)^2 \\ =151905 \dots\dots\dots (\text{Col. 8})$$

Correction term

$$= \frac{(1063)^2}{8} \\ =141246 \dots\dots\dots (\text{Col. 9})$$

Corrected sum of squares for daughters

$$=151905 - 141246 \\ =10659 \dots\dots\dots (\text{Col. 10})$$

The corrected sum of product is calculated next using the product of the yields for each pair.

Crude sum of products

$$=(176 \times 134) + (222 \times 118) + (222 \times 174) + (82 \times 136) + (32 \times 66) + (66 \times 110) + \\ (66 \times 131) + (201 \times 194) \\ =156572 \dots\dots\dots (\text{Col. 11})$$

Correction term for the sum of products

(Total for dams) (Total for daughters)

Number of pairs

$$= \frac{(1067) \times (1063)}{8}$$

$$= 141778 \dots \dots \dots (\text{Col. 12})$$

Corrected sum of products

 $= 156572 - 141778$

$$= 14794 \dots \dots \dots (\text{Col. 13})$$

If the records are available for only one sire and the number of daughter-dam pairs is large, say 50 or more, the intra-sire regression may be estimated as the quotient obtained by dividing the corrected sum of products by the corrected sum of squares for dams. But such a large number of pairs from a single sire is hardly likely to be available, the common situation being a number of sires from the same herd with much fewer daughter-dam pairs each. In such cases the corrected sums of products and the sums of squares for dams may be pooled over all sires. The intra-sire regression coefficient may then be obtained as ratio of the pooled sums of products to that for the pooled sums of squares for the dams. For the Haryana herd taken for illustration here, data in respect of ten sires were available. Computations made for these sires in the manner explained above are presented in Table II. The estimate of the intra-sire regression coefficient obtained from the pooled data is

$$= \frac{94065}{320726}$$

$$= 0.2933$$

The corrected daughter average index for Sire I is now obtained as below :
Average for dams

$$= \frac{1067}{8}$$

$$= 133.4 \dots \dots \dots (\text{Col. 14})$$

Deviation of the average for dams from the herd average

$$= 133.4 - 130$$

$$= +3.4 \dots \dots \dots (\text{Col. 15})$$

Correction for the effect of dams

$$= (\text{Dams' av.} - \text{herd av.}) \times \text{regression coefficient}$$

$$= +3.4 \times 0.2933$$

$$= +1.0 \dots \dots \dots (\text{Col. 16})$$

Average for daughters

$$\begin{aligned}
 &= \frac{1063}{8} \\
 &= 132.9 \dots\dots\dots (\text{Col. 17})
 \end{aligned}$$

Corrected Index

$$\begin{aligned}
 &= \text{Daughter av.} - \text{correction} \\
 &= 132.9 - 1.0 \\
 &= 131.9 \dots\dots\dots (\text{Col. 18})
 \end{aligned}$$

The following are the steps for computing the standard error of the index :—
Residual sum of squares

$$= (\text{corrected S.S. for daughters}) + (\text{corrected S.S. for dams}) \times (b)^2 - (\text{corrected S.P.}) \times 2b$$

where S.S. and S. P. denote the sum of squares and products, respectively.

$$\begin{aligned}
 &= 10659 + (44094) \times (0.2933)^2 - 14794 \times 2 \times 0.2933 \\
 &= 5774 \dots\dots\dots (\text{Col. 21})
 \end{aligned}$$

The divisor for the residual sum of squares

$$\begin{aligned}
 &= n \times (n-1) \\
 &= 8 \times 7 \\
 &= 56 \dots\dots\dots (\text{Col. 22})
 \end{aligned}$$

Variance of the Sire Index

$$\begin{aligned}
 &= \frac{\text{Residual sum of squares}}{\text{Divisor in Col. (22)}} \\
 &= \frac{5774}{56} \\
 &= 103 \dots\dots\dots (\text{Col. 23})
 \end{aligned}$$

Standard error of the index

$$= \sqrt{\text{Variance}} = \sqrt{103} = 10.1 \dots\dots\dots (\text{Col. 24})$$

It may be noted that in calculating the regression and the sire index the dam's record is repeated with that of each of her daughters when the number of daughters is more than one. This procedure is a close approximation to the exact but elaborate technique suggested by Kempthorne and Tandon [1953]. This method is satisfactory when the correlation between the daughters of the same dam is low and the number of full sibs is few, which is normally the case.

The method given for the calculation of the standard errors of the indices is a simplified approximation to the exact procedure, as the component term in the sampling variance due to the sampling nature of the regression estimate is neglected. The extent of under-estimation in the standard errors of the indices will, however, decrease with an increase in the volume of data on which the regression coefficient

is based. Experience in the analysis of breeding data at the Indian Council of Agricultural Research suggests that the bias involved in using the simplified method being of an order of less than one per cent is negligible, unless the data available for estimating the intra-sire regression is very scanty. The component of the sampling variance of the regression coefficient is

$$\frac{\text{Residual S.S.}}{n-1} \times \frac{(\text{Dams' average} - \text{Herds' average})}{\text{Corrected S.S. for dams from total line}}$$

and should be added to column (23) in Table II in order to obtain the exact variance of the regression coefficient. For example, the correction needed for the estimate of variance 103, corresponding to Sire I in column (23), Table II is

$$\frac{5774}{7} \times \frac{(+3.4)^2}{320727} \text{ which is less than } 0.5.$$

A frequent limitation of the estimates of the intra-sire regression coefficients obtained from the data available for a set of contemporary bulls is that they are of low precision owing to the inadequacy of the data. In these circumstances it is desirable to make use of the data for sires that may have been tested in the past from the same herd in order to obtain an estimate of the regression coefficient with a higher precision. This can be done easily by adding to the numerator and the denominator (i.e. to the corrected sum of products and the sum of squares for dams respectively) the corresponding quantities for the previous sires. The regression coefficient may then be obtained as the ratio of these two quantities. This procedure is justified since the change in the proportion of heritable variation is not likely to be appreciable in the course of a few generations with the moderate selection that is possible in small herds. In case, however, the earlier data pertain to a period in the distant past—say more than 20 or 25 years before—and a substantial change in the herd average has occurred during the intervening period, it would not be advisable to use such data.

Comparison of indices

In order to see how far the expectations of the superiority of the corrected index over the other two indices, viz. the simple daughter average index and the intermediate index is realised in practice, data relating to as many as 69 bulls for six herds were analysed. The three indices with their standard errors are given in Tables III to VIII. It will be seen from columns 7 and 9 of the Tables that the standard errors for the corrected and the intermediate indices are, generally speaking, in the ratio of 1:2 as expected. A comparison of the standard errors for the corrected and the simple average indices indicates that the gain achieved due to the reduction in the standard errors is negligible. This is not surprising as it can be seen from the results given in the Appendix I that the expected reduction in the standard errors is less than 2.5 per cent for a heritability coefficient of 50 per cent or less.

TABLE III
Comparison of different Sire Indices (Kangayam bulls, Livestock Research Station, Hosur)

Bull No.	Daughter-daughters	Dams' Average	Simple Daughter Average		Intermediate		Corrected Daughter Average		Rank according to			
			Index	S.E.	Index	S.E.	Index	S.E.	(4)	(6)	(8)	(12)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(12)
307	54	1673	1176	101	679	108	1098	90	16	15	16	16
306	45	1818	1245	94	672	170	1165	88	12	16	13	13
35	34	1442	1546	91	1050	207	1534	96	9	7	7	7
90	30	1601	1743	123	1835	217	1673	111	3	5	4	4
203	28	1645	1249	97	853	190	1179	91	11	12	12	12
231	26	1518	1182	77	846	164	1148	70	15	13	14	14
85	20	1292	1654	90	2016	212	1685	96	0	3	3	3
391	12	1408	1155	59	982	101	1183	66	14	10	11	11
104	11	2421	1706	180	991	571	1414	225	5	9	9	9
50	9	1673	1717	212	1761	362	1639	193	4	6	6	6
33	9	1293	1608	115	2013	174	1665	89	7	4	5	5
84	8	1806	1585	115	1364	347	1468	139	8	8	8	8
182	8	1729	1340	148	951	394	1246	166	10	11	10	10
554	7	1894	1073	170	252	391	931	172	17	17	17	17
39	7	2046	2360	482	2674	399	2174	460	1	1	1	1
47	7	1614	1186	115	753	320	1124	136	13	14	13	13
119	6	1873	2125	289	2307	547	1999	272	2	2	2	2

*Corresponding to the herd average of 1,400 lb.

TABLE IV
Comparison of different Sire Indices (Tharparkar bulls, Government Cattle Farm, Patna)

Bull No.	Daughter- dam sires	Dams' Average	Simple Daughter Average		Intermediate		Corrected Daughter Averages*		Rank according to		
			Index	S.E.	Index	S.E.	Index	S.E.	(4)	(6)	(8)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
39	45	3340	2704	172	2063	416	2679	176	10	11	10
26	29	3297	3128	193	2059	423	3110	198	4	5	4
599	26	3441	3160	261	2579	542	3128	203	3	6	3
24	24	3648	3020	277	2092	511	2951	238	5	10	6
1401	21	3594	3345	315	3096	618	3342	319	2	3	2
77	20	3310	2780	268	2250	438	2758	201	9	8	9
20	14	3272	2876	211	2450	351	2826	206	8	7	8
16/0	14	3783	3639	374	3495	564	3552	385	1	1	1
885	13	3454	2160	181	836	541	2125	190	13	13	13
18	10	3101	2673	172	2245	351	2666	168	11	9	11
16	8	2694	2591	256	3088	649	2713	283	7	4	7
27	6	3760	2895	565	1310	1550	2554	539	12	12	12
1/0	6	2625	2602	721	3379	1394	2629	654	6	2	5

*Corresponding to the herd average of 3,000 lb.

TABLE V
Comparison of different Sire Indices (Sindhi bulls, Livestock Research Station, Hosur)

Bull No.	Daughter- dam Pairs	Dams' Average	Simple Daughter Average		Intermediate		Corrected Daughter Average*		Rank according to			
			Index	S.E.	Index	S.E.	Index	S.E.	(4)	(9)	(10)	(11)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)				(12)
255	27	4019	2974	230	1929	497	2917	236	13	13	13	13
8	25	3651	4363	272	5075	506	4372	258	3	3	3	2
144	23	4118	3192	315	2260	713	3117	323	12	11	12	12
236	18	3860	3923	475	3986	995	3895	477	7	6	7	7
33	17	3661	4023	229	4382	306	4029	212	6	4	6	6
65	12	4029	3262	269	2405	641	3203	282	11	10	10	10
139	11	4827	4261	362	3695	509	4000	303	4	7	5	5
282	11	4320	3278	481	2236	1076	3107	490	10	12	11	11
124(0)	11	3364	3283	405	3202	933	3343	431	9	8	9	9
98	10	4490	3813	360	3127	557	3670	310	8	9	8	8
56	9	4298	5083	850	5863	1608	4976	811	1	1	1	1
238	7	4046	4470	426	4294	1096	4301	451	2	5	3	3
136(0)	6	2908	4163	318	5928	644	4288	317	5	2	4	4

* Corresponding to the herd average of 3,700 lb.

TABLE VI
Comparison of different Sire Indices (Sindhi bulls, Indian Dairy Research Institute, Bangalore)

Name of bull	Daughter- lactation index	Dams* Average	Simple Daughter Average		Intermediate		Corrected Daughter Average*		Rank according to		
			Index	S.E.	Index	S.E.	Index	S.E.	(4)	(6)	(5)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Erab	19	3363	2609	308	2635	617	2577	302	8	10	9
Zinn	10	2960	2629	209	2928	575	2587	279	10	6	8
Unique	18	2541	3258	318	4025	739	3312	324	3	2	2
Erlo	13	4117	2781	430	1445	853	2519	424	7	11	10
H. Gulam	12	2131	2603	308	3235	707	2798	302	9	5	6
Sulaiman	10	3282	2843	523	2403	723	2733	452	6	7	7
Tarman	10	2898	3197	206	3496	507	3160	242	4	4	4
Sikander	9	2542	2296	457	2550	1152	2425	462	11	9	11
Xavier	9	2470	3063	578	3617	1499	3104	628	5	3	5
H. Raj	7	2773	1810	573	847	973	1797	525	12	12	12
Warrior	7	3807	3368	442	2929	1061	3166	462	2	6	3
Victory	6	2679	3819	251	4959	651	3523	296	1	1	1

*Corresponding to the herd average of 2,760 lb.

TABLE VII
Comparison of different Sire Indices (Hariana bulls, Government Cattle Farm, Hissar)

Bull No.	Daughter-dam pairs	Dams' Average	Simple Daughter Average		Intermediate		Corrected Daughter Average		Rank according to		
			Index	S.E.	Index	S.E.	Index	S.E.	(4)	(10)	(12)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)			
I	8	1334	1329	138	1324	252	1319	101	8	9	9
II	8	1598	1554	151	910	274	1197	139	10	10	10
III	10	1813	1673	200	1533	440	1523	210	2	7	3
IV	9	1156	1349	138	1542	344	1391	153	7	6	7
V	8	1145	1438	128	1731	213	1433	101	5	2	4
VI	7	1163	1717	201	2341	385	1743	182	1	1	1
VII	6	1172	1402	247	1632	84	1440	122	6	3	6
VIII	7	1737	1667	230	1597	371	1539	200	3	5	2
IX	11	1377	1492	165	1607	364	1470	163	4	4	5
X	5	1122	1568	193	1454	378	1340	182	9	8	8

*Corresponding to the herd average of 1,300 lb.

TABLE VIII

Comparison of different Sire Indices (Gir bulls, Indian Dairy Research Institute, Bangalore)

Name of bull	Daughter- dan pairs	Dams' Average	Simple Daughter Average		Intermediate		Corrected Daughter Average*		Rank according to		
			Index	S.E.	Index	S.E.	Index	S.E.	(4)	(9)	(2)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Windfall	10	3368	3123	222	2378	280	3009	162	1	2	2
Yakub Khan	8	2192	2163	393	2134	631	2414	383	4	3	3
Rauji	5	2593	3057	444	3316	1063	3182	499	2	1	1
Wonderful	5	3189	2343	614	1497	1436	2324	672	3	4	4

*Corresponding to the herd average of 3,000 lb.

These results can be seen clearly by a comparison of the mean square errors for the three indices for all six herds (Table IX). The mean squares for the intermediate and the simple average indices, when averaged over all the herds, were about 437 and 103 per cent respectively of the mean square for the corrected index. The standard error of the corrected index, when averaged over all sires, was only 45.4 per cent of the standard error for the intermediate index and 97.8 per cent of the error for the simple daughter average index.

TABLE IX

Pooled mean square errors for the different indices
(10 lb. unit)

Herd	d.f.	Mean	Square	for
		Simple daughter average	Intermediate	Corrected
1. Kangayam (Hosur)	304	3536	12166	3173
2. Tharparkar (Patna)	223	13936	63850	13938
3. Sindhi (Hosur)	174	21177	88410	20855
4. Sindhi (Bangalore)	127	18467	80645	17716
5. Haryana (Hissar)	69	2558	9425	2189
6. Gir (Bangalore)	24	10248	38857	9806
Pooled	921	11547	48998	11219

The relative rankings of the bulls in each breed according to the three indices are given in columns (10), (11) and (12) of Tables III to VIII. It may be seen that for all the herds studied, the bull ranked first according to the corrected index retained the same rank according to the intermediate index or to the ordinary daughter average index. The only exception was the Gir herd, where the best bull would have been rated as the second best if the ordinary daughter average

index was used. For all the six herds, the worst bull would have been rated as such according to any of the three indices. The rankings for other bulls also are in close agreement. The values of the rank correlation of the corrected index with the intermediate index and the simple daughter average index are given in Table X. The rank correlations are uniformly high for all the herds, showing thereby that the use of the simple daughter average index will seldom lead to materially different conclusions, if the object is merely to order the bulls according to their relative merits, provided that the average production levels of the dams mated to different bulls do not differ to a great extent. Whenever such variations are present, or when the estimates of the sire indices are desired with a greater precision, the corrected index is to be preferred.

TABLE X
Rank correlation between different sire indices

Herd	Number of sires	Simple daughter average and intermediate	Corrected average and simple daughter average	Corrected average and intermediate
Kangayam (L. R. S., Hosur)	17	0.874	0.918	0.976
Tharparkar (Cattle Farm, Patna)	13	0.813	0.997	0.857
Sindhi (L. R. S., Hosur)	13	0.890	0.984	0.939
Sindhi (I. D. R., Bangalore)	12	0.669	0.909	0.930
Hariana (Cattle Farm, Hisar)	10	0.697	0.964	0.780
Gir (I. D. R. I., Bangalore)	4	0.600	0.600	1.000

DISCUSSION

For sire evaluation and other breeding studies, it is generally the practice in foreign countries and also in some farms in India, to take the yield in the first 300 days or the complete lactation yield when the period is less than 300 days. When such data are not available as was the case in respect of the herds other than the Hariana—taken for illustration in this paper—Sukhatme [1944] suggested that correction for the inequality in lactation period may be made by using the regression technique with lactation period as the auxiliary variable. This method has been found, however, to inflate the indices of those sires whose daughters have shown poor performances, since poor performers generally have shorter lactation periods. Raising the yield of daughters which have ceased to give milk much earlier than 300 days does not appear to be justified, as the shorter lactation length cannot be

ascribed wholly to random environmental causes. The lower lactation lengths are at least in part due to poorer genotypes. The actual lactation yield—rather than the yield adjusted for 300 days—should, therefore, be considered as reflecting the milk potentiality of the progeny. Cases where shorter lactation periods are due to the result of known abnormalities such as death of calf or diseased condition of the cow, should be omitted rather than corrected. For cows having a lactation period longer than 300 days also the yield corrected to 300 days by using regression technique does not appear to be a suitable substitute to the actual yield obtained during that period, as the regression results generally in an over-correction. This is on account of the fact that the yield in the tail end of a lactation is generally lower than the average yield per day over the entire lactation period. It is, therefore, suggested that the yield in the first 300 days of a lactation should be taken for the lactations longer than this period. A good reason for this practice is that in well organised dairy farms, it is desirable to provide for annual calvings and a dry period of about two months to help the cow maintain her health. For lactations completed in less than 300 days, the complete lactation record seems to be the appropriate one. Wherever data on the yield in the first 300 days are not available, it is preferable to carry out the studies on the unadjusted yield rather than on the yield corrected to 300 days using the regression technique.

Another factor influencing the lactation yield of a cow is the order of lactation. The effect of this factor can be eliminated by confining the study to the first lactation records only. The first lactation records are preferable to the later ones as they will be available earlier and will be influenced to a lesser extent by selection. The extent of gain that can be achieved by using the later lactation records in addition, requires further investigation.

An important consideration in planning a systematic breeding programme providing for sire evaluation is the number of daughter-dam pairs required to prove a sire. An answer to this question depends on how sure of his proof one wants to be and on the order of variability among the daughters' yields after correcting for the inequalities in the dams' performances. With the conventional 5 per cent level of significance and a coefficient of variation of the order of 40 per cent for lactation record observed in the case of the six herds already referred to, the superiority of a bull whose corrected index is 20 per cent higher than the herd average can be detected with 12 daughter-dam pairs. With the same number of pairs, it will be possible to distinguish between bulls whose corrected indices differ by more than 32 per cent at the same level of significance. Sukhatme [1944] suggested that in breeding problems the 10 per cent level of significance may be used as an aid to possible retention of superior breeding material which is difficult to select with greater certainty. If this level of significance is adopted, a difference of the order of about 28 per cent or higher will be revealed as significant. The corrected index for a sire calculated on 12 pairs of records is expected to be determined with a standard error of the order of 11 per cent.

The results indicate that, while there is no harm in using as low a number of pairs as five or six for getting the first indication of the breeding worth of a sire and for discarding inferior bulls having lower indices than the herd average, the

final selection of a bull as proved for extensive use, or for the selection of his sons for further propagation should be based on a test carried out on the records of twelve or more daughter-dam pairs. In order to provide records of 12 daughters, about 30 dams may have to be mated to a sire in order to make allowance for sex ratio, mortality of calves, etc.

SUMMARY

The limitations of the two common measures of the transmitting ability of bulls, viz. the simple daughter average index and the intermediate index have been discussed and an alternative index termed as the corrected daughter average index is proposed. This index is shown to be superior to either of the indices in current use. The detailed procedure for the calculation of the corrected index and its standard error is illustrated with the help of the data on the Hariana herd at Hissar.

The superiority of the corrected index was also demonstrated with the help of the data pertaining to 69 bulls from six herds. An examination of the relative rankings of the bulls in these herds, according to the three indices, revealed close agreement, the best and the worst bulls for a herd remaining generally the same for all the three indices. The rank correlations between any two indices are uniformly high for all the herds, showing thereby that the use of the simple daughter average index will seldom lead to materially different conclusions, if the object is merely to order the bulls according to their relative merits, provided that the average production levels of the dams mated to different bulls do not differ substantially. Whenever such variations are present, or when the estimates of the sire indices are desired with a greater precision the corrected index seems to be the appropriate one to use. Corrections for the lactation length and the order of lactation have been discussed. The number of daughter-dam pairs required to test a sire by the use of the proposed index has also been examined.

ACKNOWLEDGMENT

The author feels greatly indebted to Dr V. G. Panse, Statistical Adviser and to Shri V. N. Amble, Statistician (Animal Husbandry), I.C.A.R., for their guidance and encouragement in the preparation of this paper. He also acknowledges the permission given by the Indian Council of Agricultural Research for making use of the data collected under a Council scheme, and to the Heads and other staff of the cattle breeding farms from where the data were collected. The computational help rendered by Messrs B. B. Nayar and P. N. Soni is also acknowledged with thanks.

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APPENDIX I

Comparison of the relative efficiency of the three indices

Let σ_D^2 and σ_M^2 be the variances for the daughters and dams respectively, b the intra-sire regression of daughter's performance on that of its dam, and n the number of daughter-dam pairs.

The variance of the simple daughter average index is given by $V(\bar{D}) = \frac{1}{N} \sigma_D^2$.
The variance of the intermediate index is

$$\begin{aligned} V(I) &= V(2\bar{D} - \bar{M}) \\ &= 4V(\bar{D}) + V(\bar{M}) - 4\text{cov}(\bar{D}, \bar{M}) \\ &= \frac{1}{N} [4\sigma_D^2 + \sigma_M^2 - 4b\sigma_M^2] \\ &= \frac{1}{N} [4\sigma_D^2 + \sigma_M^2 (1 - 2h^2)] \end{aligned} \quad \text{since } h^2 = 2b$$

The variance of the corrected index is

$$\begin{aligned} V(S) &= V[\bar{D} - b(\bar{M} - A)] \\ &= V(\bar{D}) + b^2 V(\bar{M}) - 2b\text{cov}(\bar{D}, \bar{M}) + (\bar{M} - A)^2 V(b) \\ &= \frac{1}{N} [\sigma_D^2 - b\sigma_M^2] + (\bar{M} - A)^2 V(b) \\ &= \frac{1}{N} \left[\sigma_D^2 - \frac{(h^2)^2}{4} \sigma_M^2 \right] + (\bar{M} - A)^2 V(b) \end{aligned}$$

The efficiency of the corrected index relatively to the simple daughter average index is therefore,

$$\begin{aligned} \frac{V(D)}{V(S)} &= \frac{\frac{1}{N} \sigma_D^2}{\frac{1}{N} \left[\sigma_D^2 - \frac{(h^2)^2}{4} \sigma_M^2 \right] + (\bar{M} - A)^2 V(b)} \\ &= \frac{1}{1 - \frac{(h^2)^2}{4} \frac{\sigma_M^2}{\sigma_D^2}} \end{aligned} \quad \text{approximately}$$

since the term containing $V(b)$ is negligible. If it is further assumed that $\sigma_M^2 = \sigma_D^2$,

this is approximately $\frac{1}{1 - \frac{(h^2)^2}{4}}$ which is greater than unity.

The efficiency of the corrected index compared to the intermediate index is given by

$$\begin{aligned} \frac{V(I)}{V(S)} &= \frac{\frac{1}{N} [4\sigma_D^2 + \sigma_M^2 (1-2h^2)]}{\frac{1}{N} \left[\sigma_D^2 - \frac{(h^2)^2}{4} \sigma_M^2 \right] + (\bar{M}-A)^2 V(b)} \\ &= \frac{4\sigma_D^2 + \sigma_M^2 (1-2h^2)}{\sigma_D^2 - \frac{(h^2)^2}{4} \sigma_M^2} \quad \text{approximately} \end{aligned}$$

since the term containing $V(b)$ is negligible. This is clearly greater than 4 if h^2 is less than or equal to 0.5.



STUDIES ON THE SCOPE FOR IMPROVEMENT OF BELLARY SHEEP

By

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(Received for publication on October 20, 1955)

BELLARY sheep which constitute one of the main breeds of wool producing sheep available in South India are mostly found in the Bellary district of Andhra State. They are generally of two major colour patterns, (i) all black, and (ii) white body with black face, (hereafter designated W.B.F.). The output of wool of these sheep is low. Moreover, the fibres are very coarse and medullated. The mature ewes generally weigh 60 to 70 lb. The rams have a square body and do not fatten well. When mature, a ram weighs about 120 lb. and has 4 to 7 lb. of wool output per year.

In 1925, a flock of Bellary ewes was transferred from Hagari Farm in Bellary district to Hosur Farm with the object of raising through controlled breeding on the farm, a flock which would be hardy and pure white and would give a fair yield of wool. The information regarding the breeding of these sheep in the Hosur Farm for eight years was given by Littlewood [1936] as follows:

- (a) Matings of pure black ram with black ewes produced on an average seven black lambs to one W.B.F. lamb.
- (b) Matings of W.B.F. rams and ewes resulted in black and W.B.F. lambs in the ratio of 1 : 3.6. Pure white lambs also could be obtained through such matings in the proportion of about 1 in 25.
- (c) Pure white lambs were found to be of poor constitution, so much so that the majority of them died before the age of four months.
- (d) The breed responded well to good management and the average annual yield of the breed increased from $1\frac{1}{2}$ lb. to $2\frac{1}{2}$ lb. when transferred from Hagari to Hosur Farm.

As the pure white lambs were constitutionally very weak, the objective of raising a pure white flock failed. Efforts were then directed towards raising a flock having white body but a coloured face with fair amount of wool. A detailed investigation for exploring the possibilities of improving Bellary sheep through selective breeding and through grading up by means of white bodied Bikaneri rams was conducted at the Hosur Livestock Research Station from 1938 to 1952 with financial assistance from the I.C.A.R. The results of this investigation are described in this article.

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MATERIAL

The work on the scheme started with two flocks of Bellary sheep. The foundation of the pure bred flock consisted of 58 farm-bred and 24 purchased Bellary ewes—all, excepting 12, of which were white-bodied with black face, the remaining all black. The other flock, composed of 100 black Bellary ewes (all purchased) formed the foundation of the stock to be graded up with white-bodied Bikaneri rams purchased from Hissar. During the 14 years of the scheme four generations of sheep were raised from either flock, the number of lambs born in each generation are given in Table I.

TABLE I

Distribution of lambs born in the different generations

Flocks	Kind	Generation				
		I	II	III	IV	TOTAL
Bellary Flock	Male	199	65	18	4	286
	Female	202	70	26	5	303
	Total	401	135	44	9	589
Graded Flock	Male	149	79	38	17	283
	Female	142	109	56	12	319
	Total	291	188	94	29	602

The ewes were mostly mated during the months of April and May. Those which did not conceive in this season, together with others which matured in September-October, were mated during these latter months. Sire-daughter mating was avoided in order to reduce inbreeding. The ewes were shorn twice a year, once in the month of March and again in October. The lambs were weighed at birth and thereafter fortnightly up to the age of six months.

The stud rams were given 1 lb. of concentrates daily throughout the year. All the ewes were given 1 lb. of concentrates daily throughout the year except in the months of September to November, when enough of grazing was available. Culling was reduced to the barest minimum in order to permit a proper, study of the scope for improvement through selection. During the entire period, only 17 pure Bellary lambs out of 303 and 28 graded lambs out of 318 were culled. There was no culling of the adult female stock,

The salient findings from a statistical examination of the data pertaining to the two flocks are presented in the following sections separately in respect of the different aspects studied.

Colour pattern of sheep

At the outset, the findings as regards the colour pattern of the two flocks in different generations may be briefly summarised as follows :

In the case of the pure bred Bellary flock, the progenies of W.B.F. ewes in all the generations showed segregation into three patterns, pure white, W.B.F. and black in the proportions of 1 : 3 : 1; those of the black ewes were of two colours, viz. W.B.F. and black in the ratio 1 : 1. The actual distribution was as shown below together with the values of χ^2 obtained on the hypothesis that the colours were distributed in the ratio 1 : 3 : 1.

TABLE II
Frequencies of the progenies having different colours

Dams (W.B.F.)	White	W.B.F.	Black	χ^2 on 2 d.f.
Foundation ewes	80	228	90	1.86
First generation	18	48	24	2.67
Second generation	10	22	7	.78
Polled	108	298	121	3.41
Black dams	White body		Black	
Over-all generations	24		27	

The distribution of colour patterns among the graded progenies varied in the different generations. The progenies in the first generation had mixed colour, i.e. mixtures of black and white and of black and brown in 92 per cent of cases, black colour in 3 per cent of cases and W.B.F. in 5 per cent of cases. The mixed coloured progenies of the first and second generations produced W.B.F. and mixed progenies in the ratio 5 : 1. The W.B.F. progenies of the second generation again produced both W.B.F. and mixed progenies in the ratio 4 : 1. Thus about 80 per cent of the lambs born as a result of repeated crossings with Bikaneri rams had white fleece. It may, in this sense, be claimed that both the policies of breeding could attain a fair degree of success so far as fleece colour was concerned. The data pertaining to colour pattern offer an opportunity to study the inheritance of the character in question in Bellary and Bikaneri sheep. This aspect of the problem is being studied.

Mortality of lambs

The success of any breeding policy in sheep depends to a large extent on the effective control over mortality of lambs. The failure of the policy of evolving a pure white flock of ewes reported by Littlewood was actually due to the high mortality among pure white lambs. In the present case, the overall mortality of the female progenies of less than one year of age was 37 per cent and 27 per cent respectively, in the pure breed Bellary and graded flocks.

The higher mortality rate of the progenies in the pure bred flock was in this case also due to the high mortality of the pure white lambs. It is interesting to note that no such adverse effect could be found in the case of the graded progenies of the same colour. Table III shows the mortality of below one year of age of the female progenies of different colours.

TABLE III

Mortality of lambs born in different generations

Colours	Pure Bellary progenies		Graded progenies	
	No. born	Per cent dead in less than one year	No. born	Per cent dead in less than one year
Pure white	64	57.8	35	37.1
White with black face (W.B.F.)	109	35.3	116	33.6
Mixed	—	—	164	20.7
Black	70	25.7	3	33.3
Over-all	303	37.3	318	27.4

It should be mentioned that the pure white Bellary lambs either died or were culled due to poor health before maturity. All other lambs including the pure white graded lambs were free from such adverse effect.

The rates of mortality of the lambs in the four different generations did not differ materially in either flock ($\chi^2=0.36$ and 5.57 for 3 d.f. each).

Wool yield

One of the main drawbacks of the Bellary breed is its low wool yield. As stated earlier, the annual average yield is about $2\frac{1}{2}$ lb. From the data collected in the scheme, it has been found that the average yield of pure Bellary flock remained of

the same order but that of the graded flock increased to 3 lb. The life-time performances of 75 ewes of Bellary flock and 126 ewes of the graded flock are summarised in Table IV.

TABLE IV
Life-time performance of ewes

Bellary flock		Graded flock generation			Overall
		1	2	3	
No. of ewes	75	97	26	3	126
Av. No. of clips per ewe	7.5±.43	7.1	8.0	10.3	7.3±.37
Av. yield per clip per ewe (oz.)	19.2±.26	23.9	25.9	27.1	24.4±.25
Total yield per ewe (lb.)	9.1±.52	10.6	12.9	17.5	11.1±.57

In order to see how in the course of the different generations the yield changed specially in the graded flock, a detailed study for generationwise comparisons was undertaken. The variate considered for such comparisons in the Bellary flock was the total yield from the first two clips as it was found that it bears a high correlation of the order of .75 with the life-time yield of the ewes. In the graded flock the yield of wool in the third and fourth clips together, was taken for the comparisons because of the fact that in the case of some of the ewes of this flock only one clip, instead of the normal two, had been taken in the first year.

In the pure Bellary flock as might be expected no generation to generation variation could be found. The relevant results are summarised in Table V.

TABLE V
Pure Bellary flock : yield of first two clips (in oz.)

Generation	No.	Average	S.E.
Foundation stock	56	43.2	0.94
First	65	31.6	0.96
Second	12	34.2	2.24

It is clear from the Table V that the foundation stock yielded much more than the subsequent progenies. A possible explanation for this may be that whereas the foundation stock consisted of ewes selected on the basis of their performance, they were not uniformly of superior genetic merit as a consequence of which their unselected progeny did not have an equally high average yield. The poor prepotency of the rams selected to head these ewes could also be a contributory factor.

In the graded flock, the yield increased from generation to generation as can be seen from the results given in Table VI.

TABLE VI

Graded flock: total yield from the third and fourth clips (oz.)

Generations	No.	Average	S.E.
Foundation ewes	88	35.1	0.96
First	81	51.7	1.00
Second	34	56.8	1.55
Third	9	62.4	3.01

The increase observed cannot be ascribed to hybrid vigour alone as in that case the yield should have fallen in the generations subsequent to the first. As the yield actually increased from generation to generation, it can be claimed that some genetic improvement, in so far as wool yielding capacity is concerned, had been achieved through up-grading.

A comparison of the daughters' yield with that of their dams confirmed that in the pure Bellary flock, there was no significant change from generation to generation subsequent to the first. In the graded flock, however, the daughters yielded more than their dams in the first and second generations. In the third generation the daughters' yield was more than their dams' on an average, but the number of observations was too small to provide a conclusive evidence (Table VII).

TABLE VII

Daughter-dam differences in wool yield (in oz.)

(Generations of daughters)

Flock	First			Second			Third		
	No.	Av.	S. E.	No.	Av.	S. E.	No.	Av.	S. E.
Pure-bred	20	12.4	.63	12	.03	.22	..	..	..
Graded	73	15.4	.15	34	5.4	2.46	9	6.8	5.97

In order to assess the extent of scope for selection if any, among the ewes of different generations in either flock, the fraction of additive genetic variation to the total variation among the ewes in each generation or the coefficient of heritability, as it is called, was estimated by the method of intra-sire regression of daughters on dams. The estimates were obtained as given in Table VIII.

TABLE VIII

Heritability of wool yield (total of 2 clips in a year) (in oz.)

Flock	d. f.	Generations	
		Foundation stock	First
Bellary Graded	16	$-26 \pm .30$ 6	$.56 \pm 1.92$
	67	$.28 \pm .30$ 28	$.28 \pm .38$

The standard errors of the estimates are rather high, indicating the poor degree of precision with which the estimates are secured. It was not possible to secure more data for the Bellary flock as the farm bred foundation ewes were small in number and the mortality of the lambs born of them was also high. The negative estimate obtained for the pure bred Bellary foundation ewes is to be presumably attributed to this cause. The results seem to indicate that there was little genetic variability among the ewes in either flock to offer scope for improvement through selection, the improvement in the graded stock being due to the superior genotype of the Bikaneri rams.

Wool quality

Like the low yield, the quality of wool of Bellary sheep, in respect of the major attributes of length, fineness and medullation, stands in need of improvement. Medullation index of samples of wool from the shoulder region from the earlier two or three clips of the lambs as measured by rapid Benzol method, constituted the only systematic data available regarding wool quality.

The statistical analysis of the data revealed that there was significant variation in medullation from generation to generation in both the flocks. Table IX shows the changes in medullation index from generation to generation.

TABLE IX

Medullation Index (percentage)

Generation	Bellary			Graded		
	No.	Av.	S. E.	No.	Av.	S. E.
First	47	46.6	1.89	11	39.5	3.67
Second	27	41.9	2.49	48	25.6	3.14
Third	7	30.0	4.86	15	13.1	3.14

It appears from a comparison of the averages that in the graded flock the medullation percentage fell down significantly with the advance of generations. It would thus appear that the quality of wool in regard to medullation improved with successive grading to Bikaneri. But in the pure Bellary flock though up to the third generation there appears to have been a fall, the difference between the first and second generation averages is not significant. The third generation average is significantly lower than the previous two averages. In the pure-bred flock there was thus some improvement in wool quality, although none in yield.

In some farms in India the general practice is to select lambs for breeding according to the quality of wool as measured by the medullation index. It is important to study the effect of such selection on the quantity of wool. Available data were utilised to find the association between the medullation index and the quantity of wool obtained from the clip at the age of one year. The correlation coefficient between the characters was .03 in pure Bellary flock and .23 in the graded flock. Neither of the coefficients is significant. Admittedly these correlation coefficients include both genetic and environmental components and in seeking an answer to the above question it is the genetic correlation which has to be estimated. The data, however, were inadequate to allow probing deeper into the problem.

Data on length, fineness and density of wool fibres collected from only six animals in each flock were too meagre to draw any firm conclusions regarding the relative merits of the two flocks and also of the three fibre characteristics, viz. fine, strong and medullated in respect of these characters. The averages and standard error of these attributes are given in Table X.

TABLE X
Fibre attributes

Attributes	Pure Bellary					
	Ewes			Rams		
	Fine	Strong	Medullated	Fine	Strong	Medullated
Length (in)	2.0 ± 0.15	2.3 ± .15	3.8 ± .25	2.1 ± .27	2.7 ± .27	4.2 ± .18
Diameter (M)	27.5 ± 1.55	36.3 ± 1.55	.7 ± 8.24	28.4 ± 1.30	38.1 ± 1.30	112.8 ± 4.93
Fleece density (No. of fibres per sq. c.m.)	573 ± 38	120 ± 20	312 ± 19	643 ± 23	115 ± 13	310 ± 16

TABLE X—contd.

Attributes	Graded					
	Ewes			Rams		
	Fine	Strong	Medullated	Fine	Strong	Medullated
Length (in.)	2.7±.15	3.0±.15	4.4±.25	3.2±.27	3.6±.27	4.5±.18
Diameter (M)	23.1±1.55	31.2±1.55	82.5±8.24	28.5±1.80	38.7±1.30	100.7±4.93
Fleece density (No. of fibres per sq. c.m.)	509 ± 38	262 ± 20	488 ± 19	441 ± 23	345 ± 13	503 ± 10

Growth of lambs

The growth of lambs as measured by their birth weight and weaning weight and weights at the age of six months, one-year and one year-and-a-half was also studied.

As a result of grading the birth weight of lambs increased from generation to generation, but, at higher ages, the graded progenies could not maintain their gain over the pure Bellary lambs. The weight of the male Bellary lambs came to the same level as the graded ones at the age of six months, while that of the female graded lambs was slightly heavier than the pure Bellary lambs at all ages, the differences, however, were not significant. Thus in respect of growth, though there was no significant gain through grading, there was no deterioration either. Tables XI and XII show (i) the birth weight of the graded progenies in the different generations together with that of the pure Bellary progenies and (ii) the body weights of the progenies in the two flocks at different ages separately for both the sexes.

TABLE XI
Average birth weight of lambs (in lb.)

Flocks	Male		Female	
	No.	Average	No.	Average
Pure Bellary	286	6.0±0.07	303	5.5±.06
Graded lambs generation :				
First	143	6.5±.09	139	6.2±.09
Second	79	6.8±.12	108	6.5±.10
Third	38	7.4±.18	56	6.8±.17
Fourth	18	6.8±.26	13	6.5±.30

TABLE XII

Average body weights at different ages (in lb.)

Flocks	Weaning		Six months		One year		One year and a half	
	No.	Average	No.	Average	No.	Average	No.	Average
Pure Bellary M	188	26.3±.54	163	39.4±.90				
F	206	23.8±.43	186	32.8±.63	115	41.1±.91	91	55.1±1.84
Graded M	177	27.5±.56	161	39.0±.71				
F	234	26.0±.46	208	36.1±.71	115	43.6±.85	185	56.3±1.04

Comparisons of sires

For each type of breeding 14 rams were used for stud during the period of the scheme. These rams were progeny-tested with respect to birth weight of progenies and wool yield in cases where at least six dam-daughter pairs were available. The results of the test suggest that none of the Bellary rams proved outstanding in improving the progenies over their dams in these two respects. On the contrary, one ram, No. 224 brought about a significant decrease in respect of birth weight and two other rams, viz. Nos. 84 and 419 lowered the wool yield of progenies significantly, i.e. by 6.9 ± 1.2 lb. and 3.7 ± 1.3 lb. respectively, as compared against the yield of their dams.

The comparison of Bikaneri rams was complicated because of the fact that they were used at different times and consequently on groups of ewes differing in their potential level of performance as a result of grading. So the results of progeny testing cannot but underestimate the worth of rams used in later periods. One approach is to convert the yield records in later generations to first and second generation basis and then conduct the comparison. A satisfactory method for such conversion is under investigation.

From a somewhat subjective comparison of the rams taking into account the period in which they were used, it, however, appears that two of the Bikaneri rams, viz. Nos. 316 and 566 proved good, while ram No. 816 was inferior to others.

Miscellaneous studies

(a) *Study of the effect of season and pregnancy on growth of wool*: As stated earlier, there were two mating seasons, viz. April-May and September-October and the

ewes were shorn twice a year, viz. once in March-April and again in August-September. A study of the effects of seasons of clipping and pregnancy conditions independently of each other reveals that the yield of the clips taken in August-September was greater than that of the other clip. Also the pregnant ewes yield clips significantly higher than the non-pregnant ewes. Table XIII shows the average yields from the two clips and in different pregnancy conditions.

TABLE XIII

Average yield in different seasons and pregnancy conditions (in oz.)

Season of clipping	Pure Bellary flock			Graded flock		
	No.	Av.	S. E.	No.	Av.	S. E.
March-April	154	17.5	.31	216	20.0	.28
August=September	162	23.8	.31	254	29.7	.28
Pregnant	123	21.3	.32	308	27.0	.29
Not pregnant	193	18.8	.32	162	23.1	.29

(b) *Mode of change of clip yield with age of ewes* : As the ewes grow old, a stage is reached when their wool yielding capacity decreases and they prove uneconomic. As there was no culling of old ewes in the present investigation, a study was possible to find the age. Considering the ewes which lived longer, the average annual wool yield at the different ages of the ewes was obtained. A comparison of the averages shows that in the first year the yield was lower, afterwards from the second to the sixth year the yield was more or less constant, after which there was a tendency towards fall. A similar study on Bikaneri ewes in Hissar revealed that the yield had a tendency towards fall from the age of three years. As the results obtained here are not based on a sufficient number of observations, they cannot be taken as very conclusive. Another study based on relatively larger number of ewes, viz. 20 and 37 as against 9 and 18 respectively, that lived at least five years also has shown a similar trend.

TABLE XIV

Average wool yield at different ages (in oz.)

Flock	No.	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year
Pure Bellary Flock	9	35.3 ±5.1	41.1 ±5.1	37.9 ±5.1	40.4 ±5.1	40.7 ±5.8	44.9 ±5.8	39.6 ±5.8
Graded Flock	18	46.3 ±2.29	54.9 ±2.29	53.3 ±2.29	52.3 ±2.29	55.8 ±2.29	54.3 ±2.29	48.7 ±2.29

(c) *Gestation period*: The gestation period estimated from the service records of nearly 500 services in each flock came out to 150.3 days on an average for both the pure Bellary and graded ewes. It did not differ from generation to generation in any flock, nor was it affected differently by the season of lambing or the sex of the lamb carried.

(d) *Association between the birth weight of lambs and their first clip yield*: It is always the aim of breeding to get sturdier lambs at birth. While sturdiness has got its own advantages, a study conducted to find the association between birth weight and the first clip yield shows that it contributes towards greater yield also. The correlation coefficient between the two characters worked out to 0.84 for pure Bellary lambs and 0.33 for graded lambs. Both these values were significantly greater than zero indicating thereby that there is a definite positive association between the two characters.

SUMMARY

Bellary sheep which form one of the wool yielding breeds in South India are generally black in colour and are low yielders. Earlier efforts (1925-33) to get white and sturdy sheep with more yield under controlled breeding in Hosur Farm, revealed that the breed responds well to improved farming but it is not possible to get a completely white flock of pure Bellary sheep owing to the very weak constitution of the white sheep.

Efforts were next directed to the breeding of ewes with white fleece with any other face colour in the Hosur Farm under a scheme financed by the Indian Council of Agricultural Research. A statistical study of the records collected on the scheme (1938-52) has revealed the following salient features.

1. Efforts made to raise white bodied progenies by crossing Bellary ewes with white bodied Bellary rams on the one hand and by upgrading Bellary ewes with white bodied Bikaneri rams on the other proved successful.
2. Mortality of lambs was greater in pure Bellary flock than that in the graded flock.
3. The graded progenies yielded more than the pure progenies and the yield of the graded progenies increased from generation to generation from about 35 oz. per two clips in a year to about 62 oz.
4. There was a considerable improvement in the graded progenies in respect of wool quality as measured by medullation percentage which fell from about 40 to 13 in four generations. In the Pure Bellary Flock also some improvement was noticed.
5. The lambs in the graded flock recorded increase in birth weight from generation to generation. But the growth of the progenies was slower than that of the pure Bellary lambs.
6. Bikaneri ram Nos. 316 and 566 proved good as judged from the sire indexes in respect of birth weight and wool yield of progenies. Most of the Bellary rams failed to improve the progenies over their dams.

7. The wool yield from clips taken in August-September was significantly greater than that from the clips in March-April.

8. As the age of ewes increased, the annual yield showed a rise in the second year, and not much fluctuation thereafter till the seventh year of age when there was a noticeable decrease.

9. There was evidence of some positive association between the birth weight and first-clip-wool yield of lambs.

10. The average number of six-monthly clips that could be obtained from a ewe was 7.5 in the case of Pure Bellary Flock and 7.3 for graded progenies. The total wool yield from a ewe during her life-time was estimated to be on an average 9 lb. for pure Bellary ewes and from $10\frac{1}{2}$ to about 17 lb. in the successive generations of graded ewes.

ACKNOWLEDGMENT

The authors are grateful to Dr V. G. Panse, Statistical Adviser and Shri V. N. Amble, Statistician (A.H.) of the I. C. A. R. for their help in improving the paper. They are also indebted to the Superintendents of the Livestock Research Station, Hosur, Madras, under whose supervision and control the Scheme was executed and the data collected. They also acknowledge the help of the staff of the Livestock Research Station, Hosur, who conducted the scheme and collected the data and also to the staff of the Statistical Branch of the I. C. A. R., particularly Shri Iswar Dayal and Niranjan Singh who rendered all computational help for the statistical analysis of the data.

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CHEAPER HIGH PROTEIN *VERSUS* EXPENSIVE LOW PROTEIN RATIONS FOR GROWTH AND FATTENING OF PIGS IN INDIA

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(Received for publication on December 9, 1955)

IN any livestock enterprise involving meat production it is necessary to devise feed mixtures which will produce greatest gain in weight with the least cost. Swine husbandry in India has not been very profitable, since cereals specially maize considered necessary in pig feeds, are expensive and are also needed for human consumption. Theoretically, excess protein (over the current need) fed to any animal is deaminised and used as carbohydrate for energy production. This study was planned to observe whether a by-product like groundnut cake with high protein content could be introduced in the diet to replace a considerable part of the high energy maize in the feeding of swine. Maize, however, was not substituted entirely by groundnut cake because of the possibility of maize having some essential constituents such as vitamin 'A' in the form of cryptoxanthin and easily assimilable carbohydrate that are lacking in groundnut cake and which help the growth of pigs.

Keith and Miller [1938, 1941] fed rations varying in crude protein content from 12 to 27 per cent to different groups of pigs and found that maximum and most economical gains from weaning to 75 lb. were made by the pigs fed the highest per cent of protein. Almost similar results were obtained by McElroy and Lobay [1947] ; Carroll and Burroughs [1939], Crampton and Ashton [1942] ; Catron *et al.*, [1952], Becker *et al.*, [1954] and Ulrey *et al.*, [1954]. Sewell *et al.*, [1953] found that 16 to 20 per cent protein gave a slow growth in baby pigs from 2 to 30 days of age. They further noted that 32 per cent protein gave fastest growth and most efficient feed utilization, but 24 to 28 per cent protein gave relatively satisfactory results.

Reber *et al.*, [1953] reported that a diet containing 41 per cent protein produced maximum weight and feed efficiency in young pigs from 12 to 24 days of age and as the pigs approached 8 weeks of age 20 per cent protein appeared to be as efficient as the high level protein.

Dobbins *et al.*, [1950] in a feeding trial with 9 pairs of pigs concluded that yellow corn containing 11.7 per cent protein was no better than yellow corn containing 8.2 per cent when furnished with some amount of protein in ration. Warden *et al.*, [1951] while comparing various soyabean oil meals with meat and bone scrapes at two levels of protein (18 and 16 per cent) reported no significant difference in gains of pigs between the two levels of crude protein fed. The result of study conducted by Wallace *et al.*, [1954] showed that a corn-soyabean oil meal ration containing 14.3 per cent crude protein fortified with minerals and vitamins was just as satisfactory for weight gains of healthy weaning pigs fed in dry lot as rations containing 17.6 and 20.9 per cent crude protein.

The studies reported above deal with feeding conditions wherein the protein feeds in general are more expensive than carbohydrate feeds. The problem there has been to find as low a level of protein in feed as is desirable. In our country the problem is just the reverse. Protein feeds like oilcakes and pulses are cheaper than carbohydrate feeds like cereals. Therefore, it is necessary to devise a feed mixture with as high a protein content.

EXPERIMENTAL PROCEDURE

Two studies each of six months duration were undertaken. The first study started on the 18th April 1954, and terminated on the 17th October 1955 (henceforth to be referred to as summer study). The second study was undertaken from the 25th September 1954 to 26th March 1955 (henceforth to be referred to as winter study). In each study piglings born about the same time were used just after weaning (two months) and were divided into groups (A, B and A₁, B₁ for summer and winter studies respectively). Each group in each study had the same number of piglings as the corresponding group. Each pigling in each group had a corresponding pigling of the same sex and parentage in the other group. The piglings were so distributed as to have the initial total weight of each group in each study similar in the corresponding group of the same study. The distribution of piglings to each group is given in Table I.

In summer study each group had three piglings (2 males and one female) while in winter study each group had six piglings (5 females and one male). Each pigling of each group was weighed initially and thereafter weekly, throughout the period of study. Male piglings of each study were castrated at the age of one month.

Piglings of each group of each study were kept in *pukka* pens all the time.

TABLE I
Distribution of piglings to the studies

SUMMER STUDY

Group—A				Group—B			
Pig No.	Sex	No. of dam	No. of sire	Weaning weight (lb.)	Pig No.	Sex	No. of dam
51	F	16	13	22.8	50	F	16
52	M	16	13	18.0	54	M	16
53	N	16	13	17.4	55	M	16
			Total	58.2		Total	
							55.8

WINTER STUDY

Group—A ₁				Group—B ₁			
Pig No.	Sex	No. of dam	No. of sire	Weaning weight (lb.)	Pig No.	Sex	No. of dam
50	F	41	X	14.4	90	F	41
98	F	61	X	29.6	99	F	61
100	F	61	X	23.0	101	F	61
103	M	58	X	11.0	105	M	58
106	F	58	X	19.0	109	F	58
107	F	58	X	11.6	110	F	58
			Total	108.6		Total	
							111.8

(The breed of the pigs used is Middle Yorkshire)

Each group was fed *ad libitum* the concentrate mixture assigned to that group as given in Table II.

TABLE II
Concentrate mixture fed ad libitum to piglings

Constituents of ration	Summer study		Winter study	
	Group A	Group B	Group A ₁	Group B ₁
	lb.	lb.	lb.	lb.
Yellow maize	50	10	40	10
Groundnut cake	10	50	20	50
Gram	20	20	20	20
Wheat bran	20	20	20	20
Mineral mixture	5	5	3	3
Digestible protein	% 12	% 27	% 16	% 27
Total protein	16	31	20	31
Total digestible nutrients	72	75	74	75
Cost per 100 lb. (At the time of experimental period).	Rs. 14-02	Rs. 11-59	Rs. 13-40	Rs. 11-59

Note. The mineral mixture fed consisted of:
50 per cent salt
50 per cent bone meal
and 0.3 per cent potassium iodide

For the first three months of the summer study the mineral mixture in addition to the above had traces of cobalt chloride, magnesium sulphate, copper sulphate and ferrous sulphate.

The concentrate mixture in winter study for piglings of Group A₁ was slightly altered from that of Group A, to give to the ration 16 to 17 per cent digestible protein which was considered the minimum desirable for growing pigs.

The record of feed consumed by each group was maintained. At noon each day each group of piglings was supplied as much green as the pigs were able to consume in four hours. Water was available to them at all times.

In winter study one gilt of Group B₁ died on the 5th February 1955 and as such her corresponding sister of group A₁ was removed on the same day from the study.

RESULTS AND DISCUSSION

In summer study during the entire period, piglings of the Group A consumed 1649.6 lb. of concentrate mixture while the piglings of Group B consumed 1411.2 lb., 238.4 lb. less than the Group A. The total initial weights of piglings of Group A and B were 58.0 and 55.8 lb. respectively. At the end of the study the final total weights of piglings of Group A and B were 509.0 and 429.0 lb. respectively.

In winter study during entire period of the study, piglings of Group A₁ and B₁ consumed 3940.0 lb. and 3981.6 lb. of feed respectively. The total initial weight

of piglings in Group A₁ and B₁ were 108.2 lb. and 111.4 lb. respectively. At the end of 19th week and at the end of the study their total group weights were 858-0, 822.4 and 962.0, 988.0 lb. respectively.

A summary of the findings comparing the economics of two groups in each study is given in Table III.

TABLE III
The economics of high protein feed for pigs

	Summer study		Winter study	
	Group A	Group B	Group A ₁	Group B ₁
Average initial weight/pig	Lb. 19.4	Lb. 18.6	Lb. 18.0	Lb. 18.6
Average final weight/pig	169.6	143.0	192.6	197.6
Average daily gain/pig in weight	0.8	0.6	1.0	1.0
Average daily feed intake/pig	3.0	2.6	3.6	3.8
Average feed intake per lb. of gain	3.66	3.78	4.61	4.54
Average cost per lb. of gain in weight	Rs. 0.513	Rs. 0.438	Rs. 0.618	Rs. 0.526
Average sale price per pig at the end of study if slaughtered and sold retail at Rs. 0.625/lb.	106.0	89.4	120.4	123.5
Average actual feeding cost per pig from weaning to end of study	77.0	54.5	93.6	82.3
Surplus or deficit over feed cost	29.0	34.9	26.8	41.2
Net return per 100 rupees of feed expense	37.7	64.5	28.6	50.0

It can be noted from the Table III that while there is almost no difference in feed intake to produce a unit weight of flesh between groups in each study, due to low cost of high protein ration, there is considerable difference in cost in favour of high protein ration to produce a unit weight of flesh. Though this was a preliminary study with a small number of pigs and spread for a duration of one year only, there is sufficient evidence to suggest that pigs can be raised economically by substituting a higher per cent of groundnut cake in the concentrate mixture. In this study the carcass quality of the pigs fed different rations was not studied. The casual observation indicated that the low-protein-ration pigs had a thicker fat layer. However, customers normally prefer more muscle and less fat in pork products, and it would seem that high protein rations would produce meat that has greater demand.

Following the method of Snedecor [1947] weekly weight of Group A and A₁ were compared statistically with the groups B and B₁ respectively.

The results of statistical analysis are given in Table IV. The summer study indicated that the pigs fed a higher maize content ration were significantly heavier at the end of the study than the pigs fed a higher groundnut-cake-content ration. However, for the winter study the pigs fed a higher groundnut cake-ration were significantly heavier at the end of the study than the pigs of the other group. The reverse effect in summer and winter seems unexplainable. It is possible that season has its effect on assimilation of high protein ration. However, further evidence is needed to confirm or contradict such a proposition.

TABLE IV
Average weekly weights per pig fed different concentrate mixture

Summer study					Winter study		
Average weekly weights per pig in lb. (Total pigs in each group 3)					Average weekly weights per pig in lb. (Total pigs in each group : 6 till 19th week, thereafter 5)		
	Group A	Group B	Difference A-B		Group A ₁	Group B ₁	Difference A ₁ -B ₁
1	19.4	18.6	0.8		18.0	18.6	-0.6
2	21.6	20.6	1.0		20.0	22.8	-2.8
3	23.8	24.2	-0.4		17.4	18.2	-0.8
4	27.0	25.2	1.8		28.0	31.8	-3.8
5	30.6	29.2	0.4		31.4	41.8	-10.4
6	32.2	32.6	-0.4		36.2	43.4	-7.2
7	38.6	36.6	2.0		42.4	48.0	-5.6
8	42.0	42.6	0		50.4	56.8	-6.4
9	46.4	46.6	-0.2		55.6	63.6	-8.0
10	52.4	48.2	4.2		61.0	69.8	-8.8
11	58.0	54.4	3.6		67.8	73.2	-5.4
12	64.6	57.0	7.6		79.6	87.2	-7.6
13	72.8	64.0	8.8		82.0	91.2	-9.2
14	79.4	71.6	7.6		95.0	105.0	-10.0
15	89.0	82.0	7.0		101.0	106.8	-5.8

TABLE IV—*contd.*
Average weekly weights per pig fed different concentrate mixture

Summer study				Winter study		
Average weekly weights per pig in lb. (Total pigs in each group 3)				Average weekly weights per pig in lb. (Total pigs in each group: 6 till 18th week, thereafter 5)		
	Group A	Group B	Difference A—B	Group A ₁	Group B ₁	Difference A ₁ —B ₁
16	99.0	85.8	13.2	105.0	105.2	-0.2
17	105.6	87.2	18.4	104.2	119.8	-15.6
18	120.6	101.4	19.2	121.2	125.4	-4.2
19	121.4	100.0	21.4	127.0	125.6	+1.4
20	130.6	108.6	22.0	143.0	137.0	+6.0
21	137.4	114.6	22.8	151.2	157.6	-6.4
22	144.0	121.4	22.6	155.0	158.4	-3.4
23	153.4	125.4	28.0	162.2	171.8	-9.6
24	151.6	124.6	27.0	186.0	173.6	-7.6
25	160.8	132.0	28.8	173.6	180.6	-7.0
26	186.0	136.6	29.4	186.4	192.8	-6.4
27	169.6	143.0	26.6	192.6	197.6	-5.0
Mean difference = 11.82			Mean difference = -5.20			
t = 13.39**			t = 7.428**			
** Significant at 0.01 per cent level.						

** Significant at 0.01 per cent level.

SUMMARY

Two studies one in summer and the other in winter, each of 6 months duration with weaned piglings were undertaken to investigate whether groundnut cake with high protein content can be used more effectively in place of maize in pig rations.

In summer study piglings getting 12 per cent digestible protein ration containing 10 per cent groundnut cake gave significant gain in weight over piglings getting 27 per cent digestible protein ration containing 50 per cent groundnut cake. However, in winter study it was the group of piglings getting higher digestible protein ration (27 per cent) containing 50 per cent groundnut cake which gave significant weight difference over the group getting lower digestible protein ration (16 per cent) containing 20 per cent groundnut cake.

In the summer study the group of piglings getting higher groundnut cake content ration gave a net return of Rs. 64.0 for every 100 rupees of feed consumed, while the corresponding group on high maize content ration gave a net return of only Rs. 37.7, a reduction of Rs. 26.8 per 100 rupees of feed cost. In the winter study the higher groundnut-cake-fed group gave a net return of Rs. 50 per 100 rupees of feed cost. While the corresponding figure for the other group was 28.6, a difference of Rs. 21.4 per 100 rupees of feed cost.

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THE USE OF DATE PRODUCTS IN THE RATION OF THE LACTATING DAIRY COW AND THE WATER BUFFALO

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(Received for publication on March 22, 1956)

IRAQ is the largest date producer in the world having an annual production of about 350,000 metric tons. Much of this production is not suitable for human consumption and thus large quantities of dates are sold well below the prices of certain concentrates used normally for livestock feed. Although dates and date pits have been fed to cattle, sheep, and horses from very ancient times, there appears to be very little published information on the use of these products as livestock feeds. Ali, Sarsam, and McLeroy [1954] found that macerated dates (dates from which the pits have been removed) and date pits, soaked or ground, were not eaten by sheep in quantities enough to make fattening possible. In later work with fattening sheep, the feeds produced excellent results when mixed with ground barley and sesame-seed-oil meal in such proportions that the dates or date pits constituted about 34 per cent of concentrate mixture. Even higher proportions gave good results on small scale trials.

In this article a series of trials which were carried out to obtain information on the value of macerated dates and ground date pits in the concentrate mixtures fed to the lactating dairy cow and buffalo has been reported.

MATERIAL AND METHODS

Trials with the dairy cow

Three trials were carried out with dairy cows. In first two trials two concentrate mixtures containing 25 per cent and 50 per cent macerated dates were tested. In the third trial the concentrate mixture contained 40 per cent macerated dates and 25 per cent ground date pits, making a total of 65 per cent date products. The mixtures fed, together with the chemical composition of the different ingredients, are shown in Table I.

The design used was the reversal or switchback experiment involving two groups of five cows each. Rations were exchanged at the end of 30-day periods. Five-day transition periods were used just before the first 30-day period and each time a switch was made. Milk samples for butter-fat tests were taken during the transition period and at or near the middle of the 30-day period. The concentrate allowance of each cow was taken from the grain feeding tables of Morrison [1954]. The amount of concentrates fed in the three trials ranged from 3.3 lb. per day for the lower producing cows up to 14 lb. per day (for a short period) for one of the highest producing cows. The roughage was green alfalfa silage fed at the approximate rate of 9 lb. per 100 lb. of liveweight.

TABLE I
Composition of feeds

Feed	No. of analyses	Dry matter (Per cent)	Crude protein (Per cent)	Crude fat (Per cent)	Crude fibre (Per cent)	N-free extract (Per cent)	Ash (Per cent)
Barley	3	90.4	9.0	1.0	5.0	72.4	3.0
Dates pits	2	91.1	6.0	7.2	14.7	60.1	3.1
Macerated dates	1	79.5	2.6	0.5	3.4	70.8	2.2
Oats	2	89.0	9.9	2.6	7.2	65.0	1.4
Sesame oil meal	2	92.3	37.0	6.8	5.4	47.1	15.4
Wheat bran	3	88.6	13.7	3.8	9.3	41.2	6.3
Wheat screenings	2	90.7	10.8	1.4	2.8	73.5	2.1
Whole cottonseed	+	92.7	23.1	22.9	10.9	26.3	3.5
Barley—47 per cent							
Sesame meal—18 per cent							
Wheat bran—10 per cent							
Oats—25 per cent	..	90.7	14.7	2.7	6.1	61.4	5.8
<i>Non-date mixture :</i>							
Macerated dates—25 per cent							
Sesame meal—25 per cent							
Wheat bran—15 per cent							
Barley—20 per cent							
Oats—15 per cent	..	88.5	15.2	3.1	5.7	58.1	6.5
<i>25 per cent date feed :</i>							
Macerated dates—50 per cent							
Sesame meal—35 per cent							
Wheat bran—5 per cent							
Oats—10 per cent	..	85.6	15.9	3.1	4.8	54.7	7.2
<i>50 per cent date feed :</i>							
Macerated dates—40 per cent							
Dates pits—25 per cent							
Sesame meal—20 per cent							
Barley—15 per cent	..	86.6	11.3	3.5	6.9	59.7	5.2
<i>65 per cent date products feed</i>							

+ Morrison, *Feeds and Feeding*, 1964, XXI Ed.

Macerated dates were prepared by putting whole dates through a special macerating machine which removes the pits. Date pits were ground to a medium degree of fineness in a burr mill. The feed ingredients were mixed in a Hobart mixer which has a kneading type of mixing action. The machine is not a necessity for mixing dates with other feeds. The mixing can be done with hand labour by first placing macerated dates on a smooth clean surface, pouring the other ingredients over the dates, and then cutting and working them all together with a spade. The dates break up into small lumps and will no longer stick together. Whole dates may be mixed with other feeds in the same manner as the macerated dates.

RESULTS AND DISCUSSION

In all three trials with milking cows (Tables II, III and IV) the concentrate mixtures containing dates or dates and date pits were eaten very readily. There were no cases of tympany. The maximum amount of macerated dates fed per day was to cow No. 1 in the third trial. This cow received as much as 14 lb. of concentrates, 40 per cent of which (5.6 lb.) was macerated dates. At the same time she also ate 3.5 lb. of ground date pits in the 14 lb. of concentrates, making a total of 9.1 lb. of date products.

TABLE II

*Four per cent fat-corrected milk produced by two groups of cows (in lbs.)
(First trial 25 per cent macerated dates)*

Group	Cow	30-day periods			Comparison a - 2b + c
		25 per cent dates a	No dates b	25 per cent dates c	
I	1	698.7	712.3	632.6	— 93.3
	2	796.8	737.2	573.6	— 104.0
	3	753.1	769.6	774.9	— 11.2
	4	922.3	898.8	842.3	— 33.0
	5	820.4	741.5	725.4	62.8
Sum — 178.7					
II		No dates	25 per cent dates	No dates	
	6	817.7	697.7	684.5	106.8
	7	706.1	751.0	698.7	— 97.2
	8	801.3	832.7	517.9	— 346.2
	9	682.7	692.7	579.1	— 123.6
	10	996.7	902.3	609.9	— 198.0
Sum — 658.2					

Difference in favour of dates, —178.7 — (—658.2) = 479.5

In the second trial three cows (Nos. 1, 4 and 10) were sick for a part of the time and, therefore, their records are not suitable for statistical analysis. Two of the cows had mastitis, one case being the result of an external injury to the udder. The third cow (No. 1, Table III) had a sickness during the second 30-day period the cause of which was not known. She seemed to have completely recovered in the third period.

In the first trial, in which a concentrate mixture containing 25 per cent macerated dates was tested, the difference in favour of the macerated dates was not statistically significant according to the method of analysis described by Snedecor [1946]. While no attempt was made to analyse statistically the data of the second trial, it appears that the mixture containing 50 per cent macerated dates also turned out satisfactorily from the standpoint of production of milk. It should be noted that both the 25 per cent and the 50 per cent macerated date feeds (Table I) showed a slightly higher protein content than the regular herd concentrate mixture. This happened because the feed analyses of Table I were not complete at the time these mixtures were made up for the feeding trials. The proportions of the ingredients

TABLE III

Four per cent fat-corrected milk produced by two groups of cows (in lb.)
(Second trial 50 per cent macerated dates)

Group	Cow	30-day periods			Comparison a — 2b ÷ c
		50 per cent a	No dates b	50 per cent c	
I	1	591.5	415.6 (sick)	628.6	—
	2	934.8	871.8	1,073.2	264.4
	3	706.6	628.8	662.5	112.7
	4	443.7 (mastitis)	500.6	524.4	—
	5	609.9	454.5	505.0	205.9
II		No dates	50 per cent dates	No dates	
	6	588.3	633.8	685.4	6.1
	7	605.4	584.5	491.9	—71.7
	8	551.4	510.5	591.3	121.7
	9	656.4	596.4	603.7	67.3
	10	747.5	787.7	(mastitis)	..

in the mixtures had to be based on estimates of the composition of some of the ingredients. The protein percentages of the regular non-date mixture and both the 25 per cent and 50 per cent date mixtures should provide more than enough protein for cows receiving legume soilage. In the last trial, the lower protein percentage was planned deliberately to see if the usual level of production could be maintained on a lower level of protein in the concentrate. From Table IV it can be seen that the difference was in favour of the non-date mixture but the difference was not statistically significant. Because of the high protein content of alfalfa there would be reason to expect that a lower protein concentrate mixture would be satisfactory for milk production. The use of high protein alfalfa permits the use of low protein high-energy date feeds. It may be possible to reduce further the protein of the concentrate mixture without serious detriment to milk production; thus, dates may have their greatest value when the roughage is high quality legume.

The results obtained with feeding dates and date pits should encourage greatest use of these feeds in dairy cow concentrate mixtures. According to the prices prevailing during these three trials, the cost of a ton of macerated dates or ground date pits was less than half the cost of a ton of barley. Since these feeds are lower in protein than barley it is necessary to provide more protein-rich supplement and that increases the cost somewhat; but even so the ingredients in the 25 per cent date mixture cost 83.6 per cent of those in the non-date feed; the ingredients in the 50 per cent mixture cost 77.2 per cent and the ingredients of the date-date pit mixture cost 65.4 per cent. The results with the last mixture suggested that lower protein combinations may be used successfully when high quality legume roughage is fed, thus effecting even greater saving in the purchase of the protein-rich supplements.

Trial with water buffalo

During the summer of 1955, a feeding test with lactating buffaloes was carried out in co-operation with a herd owner in Baghdad. Due to the fact that the Experiment Station had no herd of buffaloes, it was necessary to seek the co-operation of a private owner in carrying out a rather crude feeding test. During the summer of 1955, a buffalo owner in Baghdad agreed to co-operate in a short trial. The plan followed was to feed first for one week a mixture made up of equal parts of barley, wheat bran, and wheat screenings. The mixture was poured over barley straw and the buffaloes were allowed to eat all they wanted. The average consumption of concentrates was about 32 lb. per buffalo per day. Unfortunately there was no way to feed each buffalo individually. Green alfalfa was fed at about the rate of 10 lb. per buffalo per day. Production was recorded by one of the authors who visited the herd twice daily at milking time. On the seventh day samples of milk were taken from each buffalo and tested for fat.

The method of feeding used in the first week appears to be fairly typical of what may be found in the Baghdad area, except for the use of a higher fat concentrate. Buffalo herdsmen insist that a high-fat concentrate such as whole cottonseed or rice bran will increase the yield of *genmer* (buffalo cream). In the second seven-day

TABLE IV

Four per cent fat-corrected milk produced by two groups of cows (in lb.)
(Third trial, 65 per cent date products)

Group	Cow	30-day periods			Comparison $a - 2b + c$
		40 per cent dates, 25 per cent date pits a	No dates b	40 per cent dates, 25 per cent date pits c	
I	1	7941.5	980.4	962.9	-56.4
	2	762.8	805.1	679.4	-168.0
	3	751.6	822.3	702.1	-190.9
	4	653.6	640.6	673.0	45.1
	5	809.8	820.3	731.9	-95.9
Sum -465.8					
II		No dates	40 per cent dates, 25 per cent date pits	No dates	
	6	744.9	725.6	620.7	-84.4
	7	735.6	763.0	619.2	-171.2
	8	867.0	869.6	879.8	7.6
	9	538.0	511.7	404.0	-81.4
	10	744.2	644.0	639.6	95.8
Sum -233.6					
Difference in favour of no dates, -233.6 - (-465.8) = 232.2					

period, following a two-day period allowed for changing the ration, a mixture containing 25 per cent each of barley, wheat bran, wheat screenings, and whole cottonseed was fed. In the third seven-day period the concentrate mixture was changed to 25 per cent whole cottonseed, 30 per cent macerated dates, 15 per cent wheat screenings, 7.5 per cent sesame-seed-oil meal, and 7.5 per cent barley. After allowing two days for the buffaloes to become accustomed to this mixture the production was recorded for seven days. The calculated chemical compositions of the mixtures are given in Table V. The average daily production of the ten buffaloes for the three seven-day periods may be found in Table VI.

TABLE V

Composition of concentrate mixtures fed to buffaloes

Concentrate mixture	Dry matter per cent	Crude protein per cent	Crude fat per cent	Crude fiber per cent	N-free extract per cent	Ash per cent
Mixture No. 1						
Barley 33½ per cent						
Wheat bran 33½ per cent						
Wheat screenings 33½ per cent	91.3	11.2	2.1	5.7	69.0	3.5
Mixture No. 2						
Barley 25 per cent						
Wheat bran 25 per cent						
Wheat screenings 25 per cent						
Cottonseed 25 per cent	91.8	14.1	7.3	8.5	58.4	3.4
Mixture No. 3						
Macerated dates 30 per cent						
Sesame meal 7.5 per cent						
Wheat bran 15 per cent						
Wheat screenings 15 per cent						
Barley 7.5 per cent						
Cottonseed 25 per cent	88.4	13.7	7.3	7.8	55.6	4.6

TABLE VI

Seven-day average production of milk and fat tests of buffaloes fed on three concentrate mixtures

Animal No.	Mixture No. 1		Mixture No. 2		Mixture No. 3	
	33½ per cent barley 33½ per cent wheat bran 33½ per cent wheat screenings		25 per cent barley 25 per cent wheat bran 25 per cent wheat screenings 25 per cent cottonseed		25 per cent cotton seed 30 per cent dates 7.5 per cent sesame meal 15 per cent wheat bran 16 per cent wheat screenings 7.5 per cent barley	
	Milk (lb.)	Fat (per cent)	Milk lb.	Fat (per cent)	Milk lb.	Fat (per cent)
1	18.8	7.6	19.2	8.5	20.4	8.1
2	10.6	6.0	15.7	8.1	16.6	8.3
3	19.3	6.9	20.0	8.2	21.6	8.1
4	17.8	7.0	17.0	8.8	18.4	7.9
5	18.0	6.4	17.5	7.0	14.2	6.6
6	10.8	9.2	10.6	9.1	10.8	8.0
7	10.0	10.0	17.1	9.8	19.1	9.4
8	19.7	7.0	26.5	7.7	28.1	8.1
9	12.6	10.2	11.7	10.5	12.2	10.5
10	13.6	7.8	12.0	9.5	11.7	8.7
Average	16.0	7.5*	16.9	8.6*	17.3	8.3*

* Weighted average.

RESULTS AND DISCUSSION

Adding whole cottonseed to the concentrate mixture might have had some effect on the fat tests, as the average fat tests of the second and third periods were higher than the first period. Individually, eight of the buffaloes showed an increase in the second and third periods but two (Nos. 6 and 7) showed a slight decrease. Since there are so many uncontrolled factors which may have affected the fat tests, these results offer only a bare hint that cottonseed helps the fat test. Perhaps more critical tests could be devised on this point. It should be noted that in addition to increasing the fat content of the concentrate mixture cottonseed also increases

the protein content. When the animals were given the concentrate mixture containing dates the production was maintained. The trial gives some evidence that date feeds will be palatable to the buffalo and that they are not likely to depress production. Further work on this problem is contemplated.

SUMMARY

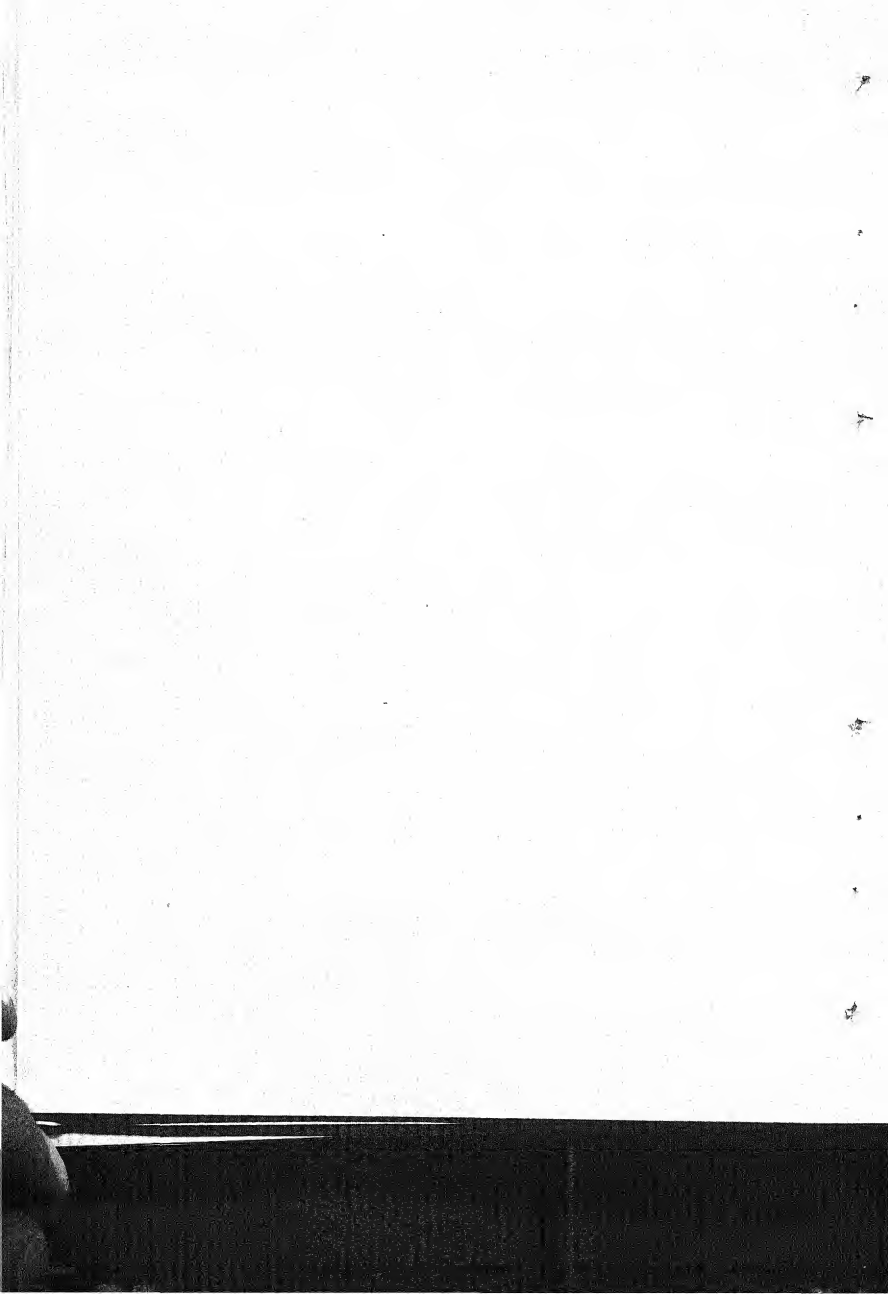
In three different reversal trials involving 30 lactating cows it was possible to secure relatively good milk production when three concentrate mixtures containing 25 per cent macerated dates, 50 per cent macerated dates, and 40 per cent macerated dates plus 25 per cent ground date pits were compared with a non-date containing control mixture. Loss of data due to sickness prevented a statistical analysis of the trial with 50 per cent macerated dates, but in the case of the other two date containing concentrate mixtures there were no significant differences between them and the control mixture as measured by the production of 4 per cent fat-corrected milk. Satisfactory results were also obtained when a concentrate mixture containing 30 per cent macerated dates was fed for a seven-day period to 10 lactating buffaloes. Macerated dates and ground date pits were eaten readily when mixed with other feeds. The maximum amount of dates consumed by any one cow was 5.6 lb. per day. The chief advantage of the date feeds was their low cost per ton.

ACKNOWLEDGMENTS

The authors thank the Date Association of Iraq for providing the macerated dates and ground date pits used in this investigation. Mr Frank Winter of the United Nations Food and Agriculture Organization Mission to Iraq and Dr Ghazi Hamid, Technical Director of the Date Association were particularly helpful in making the necessary arrangements to obtain the dates and mix the feeds. Mr Denha Iwass Mekhael, Agricultural Chemistry Section, Abu-Ghraiib Experiment Station made most of the chemical analysis of the feeds.

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EFFECT OF AUREOMYCIN AND VITAMIN B₁₂ ON THE GROWTH OF WEANED PIGS FED A HIGH-PROTEIN DIET

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(Received for publication on April 24, 1956)

(With one text-figure)

IT is generally agreed that the use of aureomycin or terramycin tends to increase the rate of gain in weight when fed to growing pigs. Catron *et al.*, [1952] found that when fed 10 mg. aureomycin per pound of ration, the pigs gained an average of 0.12 lb. more per day and consumed 2.3 lb. less feed per 100 lb. gain than the pigs receiving the antibiotic. Burnside *et al.*, [1951] compared the effect of aureomycin when fed with high, intermediate and low protein levels and concluded that the aureomycin improved all rations. Hoeffler *et al.*, [1952] fed terramycin at 5 mg. per lb. of total ration and observed a highly significant effect on the rate of gain and also improved efficiency of the gain. Terrill *et al.*, [1952] fed 5 mg. aureomycin hydrochloride per lb. of a 20 per cent crude protein "corn, solvent-soybean-oil-meal", ration properly fortified with minerals and vitamins to pigs from weaning to 100 lb. weight. They report a 27 per cent increase in rate of gain (highly significant) from the use of aureomycin. Ashton *et al.*, [1955] fed aureomycin to pigs on various levels of protein from 10 to 20 per cent. As the per cent of protein in the diet was increased from 10 to 20 there was a decrease in back-fat depth and an increase in per cent of lean cuts. They report that the pigs fed on a ration containing 20 per cent protein resulted in carcasses with a significantly greater proportion of lean than those on rations containing lower amounts of protein. Lassiter *et al.*, [1955] compared various levels of protein from 10 to 20 per cent for growing pigs and found that the feed requirements per lb. of gain decreased somewhat when protein levels increased to 16 per cent. Braude *et al.*, [1953] in a review of literature on the use of antibiotics in swine nutrition, report that in experiments conducted throughout the United States, aureomycin increased the daily gain of growing swine about 35 per cent. Davey *et al.*, (1955) fed aureomycin at different rates to three generations of swine and noted no adverse effect upon birth weight or weaning weights. Feeding at the rate of 50 mgm. per lb. feed gave the highest daily gain. Hanson *et al.*, (1955) found that the addition of vitamin B₁₂ in the ration for pigs gave a highly significant increase in the rate of gain. The addition of aureomycin produced an additional significant increase in the rate of gain.

Most of the work done on the feeding of aureomycin to pigs has been with normal or below normal levels of protein, with the main object to save expensive protein supplement. In certain areas of India groundnut cake is cheaper than cereals such as maize, wheat or barley. Agarwala and Sundaresan [1955] found that the pigs on a ration containing 27 per cent protein (50 per cent groundnut cake, 10 per cent maize, plus other ingredients) made cheaper gains than the pigs on a 16 per cent ration (20 per cent groundnut cake, 40 per cent maize, plus other ingredients).

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With the economic relationship between cereal grains and groundnut cake favouring a ration much higher in protein than that usually fed to swine, it was considered desirable to determine the effect of aureomycin and vitamin B₁₂ when fed to swine on a high-protein-low-maize diet.

EXPERIMENTAL

Sixteen weaning pigs, four barrows and twelve gilts from three litters, were separated into two groups by arranging them in pairs according to litter, sex, size and general health, then randomly assigning one pig of each pair to each group. The groups were assigned by chance to one of two adjacent pens and one group was designated by chance as the treatment group with the other as control. Weights of individual pigs were recorded at the beginning and at weekly intervals throughout the experiment. Group B or control group had free access at all times to the basic ration as shown in Table I. Group A or treatment group received the basic ration to which had been added 27 gm. aureomycin and 27 mgm. vitamin B₁₂ per ton of ration. This ration was self fed in the same type of feeder as that used in Group B. A small portion of greens was given in equal amounts to each group daily. Records were kept of the amount of feed consumed by each group. Water was provided at all times to both groups.

TABLE I
Composition of basic ration

Ration	Per cent
Maize	10
Groundnut cake	47
Gram	20
Wheat bran	20
Fish meal	3

Plus regular Institute mineral mixture (50 per cent salt, 50 per cent steamed bonemeal, plus 0.03 lb. potassium iodide per 100) at the rate of 3 lb. per 100 lb. of ration.

The experimental period was 26 weeks.

RESULTS AND DISCUSSION

There was a significant difference in average gain per pig in four weeks and five weeks of feeding in favour of the group A pigs fed aureomycin and vitamin B₁₂. After six weeks feeding the difference was not quite significant at the 5 per cent level of probability. There was no significant difference in total gains after six weeks feeding. There was no significant difference in total gains for the 26 weeks feeding period. The treated pigs had a greater average gain than the control pigs at the end of each week throughout the experiment (Table II). The greatest difference occurred after 16 weeks of feeding when the treated group averaged 24 lb. more than the untreated group. This difference was not statistically significant.

TABLE II
Initial weights, total gain at indicated periods and final weights of treated and untreated pigs

Group A—Treatment		Total gain per pig at indicated periods after weaning								Final weight (lb.)
Pig No.	Initial weight (lb.)	4 weeks	5 weeks	6 weeks	8 weeks	12 weeks	10 weeks	20 weeks	28 weeks	
1a	20.0	30.0	32.0	43.0	50.0	93.0	132.0	150.0	105.0	215
2a	26.0	34.0	41.0	55.0	71.0	117.0	140.0	160.0	231.0	237
3a	19.1	17.9	21.9	31.9	46.9	87.0	114.9	134.9	165.0	186.0
4a	18.5	20.5	23.5	30.5	31.5	(Pig died from pneumonia)				
5a	16.9	12.1	14.1	23.1	33.1	70.1	102.1	133.1	173.1	175
6a	11.2	11.8	13.8	19.8	28.8	57.8	58.8	76.8	119.8	131
7a	11.1	9.9	13.9	18.9	25.9	70.9	105.9	134.9	173.9	185.0
8a	11.5	9.0	3.5	8.5	21.5	38.5	38.5	60.5	113.5	125
Avg :	16.8	14.5*	20.8*	29.1	37.5	65.4	90.7	125.7	168.1	184.7
Group B—Control										
1b	21.8	10.2	19.2	29.2	43.2	89.2	108.2	133.2	175.2	197
2b	15.9	14.1	15.1	25.1	34.1	65.1	73.1	114.1	149.1	193
3b	23.2	16.8	10.8	37.8	44.8	70.8	104.8	112.8	173.8	197
4b	19.1	5.9	5.9	12.9	20.9	(removed because ill)				
5b	13.7	0.0	1.3	2.3	2.3	9.3	23.3	52.3	101.3	115
6b	10.7	1.3	6.3	10.3	19.3	54.3	80.3	109.3	164.3	175
7b	14.0	4.0	5.0	7.0	15.0	41.0	42.0	76.0	112.0	132
8b	19.0	9.0	12.0	18.0	41.0	64.0	88.0	121.0	161.0	180
Average	17.2	8.5	16.3	17.3	27.8	47.3	75.7	107.7	142.9	165.6

*Difference significant P-0.05 (Student's Method).

After 18 weeks feeding the difference in average gain remained fairly uniform (Fig. I). There is evidence to indicate that aureomycin and vitamin B₁₂ gave a growth stimulus during first 16 weeks of feeding, although this was not statistically significant.

Pigs 1a, 1b, 2a, 2b, 3a and 3b were from one litter, 4a, 4b, 5a and 5b from another litter and 6a, 6b, 7a, 7b, 8a and 8b were from a third litter. The pigs in this litter were about three weeks younger than the others at the beginning of this project.

The average daily gain for the 26 week-feeding period was 0.9 lb. daily for the treated group and 0.8 lb. daily for the control group (Table III).

TABLE III

Initial weight, final weight, average daily gain, feed per lb. gain and cost per lb. gain from weaning through 26 week-feeding period

	Group A (Treatment)	Group B (Control)
Average initial weight	16.8 lb.	17.2 lb.
Average final weight	184.7 "	165.6 "
Average daily gain	0.9 "	0.8 "
Average feed per lb. gain	4.0 "	2.9 "
Average cost per lb. gain	Rs. 0.55	Rs. 0.32
Total feed consumed	4,669 lb.	4,060 lb.

The average feed per lb. gain was 4.0 lb. for the treated group and 3.9 lb. for the control. With the price of Aurofac (1.8 gm. and 1.8 mgm. per lb.) at Rs. 8 per lb. it was not economical to feed the antibiotics in this test.

SUMMARY

Weanling pigs fed a ration fortified with 27 gm. aureomycin and 27 mgm. vitamin B₁₂ per ton of feed made significantly higher gains after 4 weeks and 5 week's feeding, than control pigs not receiving the antibiotic and vitamin B₁₂. The difference in gain was not quite significant after 6 weeks feeding.

The aureomycin-fed pigs made a higher average gain in 10 weeks than control pigs although the difference was not statistically significant at the 5 per cent level of probability.

From 16 weeks to 26 weeks feeding there was very little difference in rate of growth between treated and control groups.

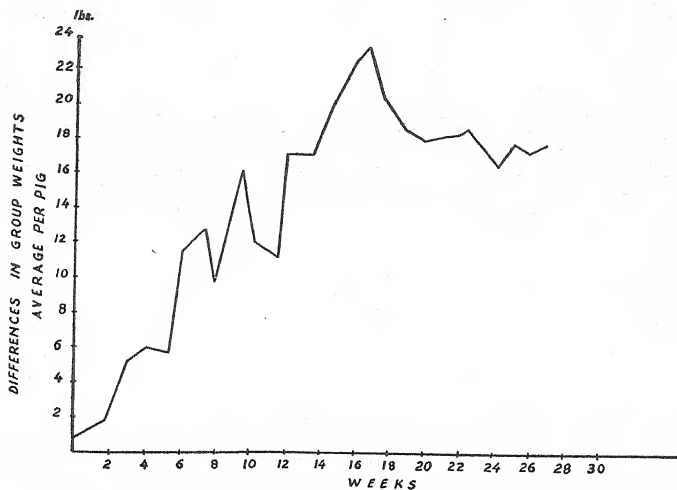


Fig. 1. The difference in average gain of treated over untreated pigs at weekly intervals from weaning through 26 weeks feeding period.

Treated pigs made a slightly higher daily gain and required slightly more feed per pound gain than control pigs during 26 weeks feeding.

The results of this experiment indicate that there is no advantage in feeding aureomycin and vitamin B₁₂ more than 16 weeks.

Although aureomycin and vitamin B₁₂ gave a significant increase in growth up to 5 weeks feeding, further evidence is needed to determine if this increase is economical.

ACKNOWLEDGMENT

The authors gratefully acknowledge the kindness of Lederle Laboratories (India) Ltd., Bombay, for furnishing the Aurofac (aureomycin and vitamin B₁₂) used in this experiment.

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APPENDIX I

Weight of individual pigs at successive weeks after weaning (in lb.)

(With Aurolac)

GROUP A

Weeks after weaning	1a	2a	3a	4a	5a	6a	7a	8a
0	29.0	26.0	18.1	18.3	16.9	11.2	11.1	11.5
1	29.0	28.0	22.0	20.0	20.0	13.0	12.0	15.0
2	30.0	28.0	25.0	24.0	20.0	13.0	12.0	15.0
3	30.0	49.0	29.0	33.0	24.0	20.0	17.0	13.0
4	50.0	60.0	37.0	39.0	29.0	23.0	21.0	11.0
5	52.0	67.0	41.0	45.0	31.0	25.0	25.0	15.0
6	53.0	67.0	45.0	45.0	31.0	25.0	25.0	17.0
7	65.0	89.0	62.0	46.0	46.0	34.0	39.0	26.0
8	70.0	97.0	62.0	50.0	50.0	40.0	40.0	26.0
9	89.0	107.0	73.0	..	50.0	40.0	40.0	26.0
10	102.0	118.0	85.0	..	69.0	55.0	60.0	23.0
11	105.0	125.0	91.0	..	75.0	61.0	67.0	25.0
12	118.0	143.0	107.0	..	87.0	69.0	82.0	39.0
13	113.0	139.0	105.0	..	102.0	72.0	84.0	38.0
14	113.0	139.0	105.0	..	102.0	72.0	84.0	38.0
15	113.0	172.0	127.0	..	111.0	78.0	109.0	56.0
16	112.0	172.0	134.0	..	119.0	79.0	112.0	50.0
17	112.0	162.0	134.0	..	122.0	77.0	122.0	50.0
18	160.0	190.0	146.0	..	130.0	76.0	136.0	59.0
19	168.0	206.0	151.0	..	138.0	88.0	139.0	60.0
20	170.0	210.0	154.0	..	150.0	88.0	146.0	72.0
21	185.0	232.0	165.0	..	154.0	107.0	165.0	86.0
22	185.0	233.0	165.0	..	154.0	107.0	165.0	86.0
23	192.0	238.0	175.0	..	180.0	118.0	168.0	102.0
24	193.0	253.0	185.0	..	184.0	127.0	175.0	118.0
25	211.0	254.0	176.0	..	192.0	131.0	184.0	118.0
26	215.0	257.0	186.0	..	195.0	132.0	185.0	135.0
Total gain	105.0	231.0	165.0	..	178.1	119.8	175.9	113.5



APPENDIX II

Weights of individual pigs at successive weeks after weaning (in lb.)

(Without Anrofacc)

GROUP B

Weeks after weaning	1b	2b	3b	4b	5b	6b	7b	8b
0	21.8	15.9	23.2	19.1	13.7	10.7	14.0	19.0
1	27.0	20.0	30.0	22.0	17.0	14.0	19.0	24.0
2	26.5	20.0	30.0	20.0	15.0	10.0	10.0	2.1
3	30.0	23.0	35.0	22.0	13.0	13.0	17.0	22.5
4	28.0	30.0	40.0	25.0	11.0	12.0	18.0	28.0
5	41.0	31.0	48.0	25.0	13.0	17.0	17.0	31.0
6	51.0	41.0	61.0	32.0	19.0	21.0	21.0	37.0
7	57.0	36.0	62.0	35.0	13.0	22.0	32.0	45.0
8	70.0	50.0	68.0	40.0	16.0	30.0	28.0	60.0
9	78.0	53.0	73.0	..	13.0	33.0	31.0	53.0
10	88.0	67.0	90.0	..	20.0	48.0	40.0	70.0
11	93.0	73.0	94.0	..	20.0	53.0	57.0	75.0
12	91.0	81.0	103.0	..	23.0	65.0	55.0	83.0
13	106.0	82.0	107.0	..	23.0	62.0	57.0	89.0
14	110.0	118.0	118.0	..	25.0	75.0	58.0	95.0
15	119.0	103.0	123.0	..	35.0	83.0	53.0	109.0
16	130.0	94.0	128.0	..	42.0	91.0	56.0	107.0
17	132.0	102.0	142.0	..	50.0	93.0	65.0	122.0
18	146.0	113.0	146.0	..	50.0	106.0	68.0	127.0
19	156.0	124.0	156.0	..	61.0	116.0	82.0	128.0
20	160.0	130.0	166.0	..	66.0	120.0	90.0	140.0
21	164.0	140.0	170.0	..	75.0	126.0	92.0	147.0
22	171.0	153.0	175.0	..	80.0	135.0	105.0	163.0
23	180.0	156.0	186.0	..	94.0	146.0	115.0	178.0
24	185.0	163.0	193.0	..	103.0	156.0	123.0	175.0
25	204.0	174.0	190.0	..	114.0	166.0	128.0	178.0
26	197.0	165.0	197.0	..	115.0	175.0	132.0	180.0
Total gain	175.2	149.1	173.8	..	101.3	164.3	118.0	161.0

SYSTEMATIC SURVEY OF HELMINTH PARASITES OF DOMESTICATED ANIMALS IN INDIA

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(Received for publication on November 10, 1955)

THE work forming the basis of the present communication was carried out under a scheme of the Indian Council of Agricultural Research at the Lucknow University.

The main object of the scheme was to study the helminthic infections of the domesticated animals in the States of Uttar Pradesh, Bihar, Bengal (including East Bengal), Assam and Orissa. This survey was carried out throughout the area spread over several years by visiting important places in different States from time to time and examining the slaughtered animals at the abattoirs and collecting the parasites recovered for identification. Some material was also received from the Department of Animal Husbandry of the above mentioned States, probably collected by their staff during their routine examinations of the diseased animals at the veterinary hospitals. Thus, Thapar and Sinha [1945] reported a new genus *Olveria* with *O. indica* as the type species from the cattle and buffaloes at Lucknow. Tandon [1945] described a second species, *Olveria bosi*, from the buffaloes at the slaughter houses at Lucknow, thereby establishing the validity of the genus. Tandon [1955] gave an account of a rare parasite, *Paramphistomum gotoi*, recovered from buffaloes in India in large numbers.

The work was extended to the study of the seasonal variations and the incidence and intensity of infection of helminth parasites of cattle, sheep, goats and buffaloes by taking a sample of each animal at the slaughter houses. This was particularly done at the headquarter where facilities were available for daily examination, by random sampling of each type of animal, and this was fairly accurate. Faecal samples received from several places in this area were also reported. The sphere of our activities was further extended to the examination of the ponds and other water reservoirs for the recovery of larval forms from the molluscan intermediaries, examination of the sullage farms for eggs and larvae, and the study of the eggs and larvae outside the body of the hosts. As a result of these investigations life histories of some of the parasites were studied in the scheme. Thus, Sinha [1950] described the life history of *Cotylophoron cotylophorum*. Thapar and Tandon [1952] gave a detailed account of the life history of the common liver fluke of India, *Fasciola gigantica*, from the cattle and buffaloes from India. Later Thapar and Singh [1954] described the life history of *Trichuris* (*Trichocephalus*) *ovis* of sheep and goats.

In the course of our investigations, several methods for the study of the morphology and life histories of the helminth parasites were evolved or improved upon which have been reported in the works already published. Data thus established have



given a clear picture of the position of the helminthic infections of the domestic animals and the mode of their spread in the region under review. All these results help in the study of the control measures and can be applied under field conditions.

I. SYSTEMATIC SURVEY OF HELMINTH PARASITES

A large number of animals have been examined and a fairly large number of new records of parasites at the localities and in the hosts are reported in Tables I—IV.

TABLE I

Description of the localities with new records of parasites in "buffaloes" in the States of U. P., Bihar, Bengal, Assam and Orissa

Name of the parasites	Location in host	Locality with new record
<i>Cotylophoron cotylophorum</i>	rumen	Agra, Azamgarh, Bareilly, Gorakhpur, Jaunpur, Kanpur, Lucknow, Meerut, Moradabad, Muzaffarnagar, Saharanpur (U.P.) Patna, Dinapur and Ranchi (Bihar) Burdwan, Calcutta, Chittagong, Dacca, Dinajpur, Howrah, Jalpaiguri, Jessore, Kharagpur, Raiganj, Rangpur, Tippera (Bengal) Silchar (Assam)
<i>Carmyriorius spatiosus</i>	rumen	Bareilly and Lucknow (U.P.)
<i>Gastrothylax crumenifer</i>	rumen	Agra, Azamgarh, Badaun, Bareilly, Gonda, Gorakhpur, Lucknow, Muzaffarnagar, Saharanpur, Shahjahanpur (U.P.) Dinapur, Katihar, Patna and Ranchi (Bihar) Barisal, Burdwan, Bogra, Dinajpur, Dacca, Calcutta, Chittagong, Jalpaiguri, Jessore, 24 Parganas, Raiganj (Bengal) Silchar (Assam)
<i>Homalogaster polonius</i>	caecum	Lucknow (U.P.)
<i>Fischoederius cobboldi</i>	rumen	Lucknow (U.P.)
<i>Fischoederius elongatus</i>	rumen	Lucknow (U.P.)
<i>Oteeria indica</i>	rumen	Lucknow (U.P.)

TABLE I—(contd.)

Name of the parasites	Location in host	Locality with new records
<i>Oleeria bosi</i>	rumen	Lucknow (U.P.)
<i>Paramphistomum cervi</i>	gall bladder, liver and bile duct	Agra, Badaun, Bareilly, Gonda, Gorakhpur, Lucknow, Meerut, Moradabad, Muzaffarnagar, Saharanpur (U.P.) Dinapur, Muzaffarpur, Patna, Sasaram, Ranchi (Bihar) Sambalpur (Orissa) Dacca, Darjeeling (Bengal)
<i>Paramphistomum explanatum</i>	Rumen, duodenum	Lucknow, Muzaffarnagar (U.P.) Muzaffarpur (Bihar)
<i>Paramphistomum gotoi</i>	rumen	Lucknow (U.P.)
<i>Paramphistomum orthocoeclium</i>	rumen	Gonda, Lucknow, Moradabad, Muzaffarnagar, (U.P.)
<i>Fasciola gigantica</i>	liver, bile duct	Agra, Badaun, Bareilly, Azamgarh, Kanpur, Gorakhpur, Lucknow, Meerut, Moradabad, Muzaffarnagar, Saharanpur (U.P.) Dinapur, Muzaffarpur, Patna, Ranchi, Sasaram (Bihar) Puri, Sambalpur (Orissa) Calcutta, Darjeeling (Bengal)
<i>Schistosoma indicum</i>	portal veins	Lucknow, Jhansi (U.P.) Ranchi (Bihar) Sambalpur (Orissa)
<i>Ascaris lumbricoides</i>	intestine	Saharanpur (U.P.)
<i>Ascaris vitulorum</i>	faeces	Muzaffarpur (Bihar)
<i>Bunostomum trigonocephalum</i>	intestine	Lucknow (U.P.)
<i>Haemonchus contortus</i>	intestine	Lucknow (U.P.)
<i>Mecistocirrus digitatus</i>	intestine, abomousum duodenum	Agra, Bareilly, Gorakhpur, Lucknow, Moradabad (U.P.) Purulia (Bihar)

TABLE I—(contd.)

Name of the parasites	Location in host	Locality with new record
<i>Oesophagostomum columbianum</i>	caecum	Lucknow (U.P.)
<i>Oesophagostomum radiatum</i>	caecum	Lucknow (U.P.)
<i>Setaria labiatopapillosa</i>	peritoneal cavity	Agra, Badaun, Bareilly, Etawa, Gonda, Gorakhpur, Jaunpur, Lucknow, Meerut, Moradabad, Muzaffarnagar, Saharanpur (U.P.) Dinapur, Patna, Ranchi, Sasaram, Muzaffarpur, Purulia (Bihar) Sambalpur (Orissa) Calcutta, Dacca (Bengal) Silchar (Assam)
* <i>Gongylonema pulchrum</i>	oesophagus, gullet	Lucknow (U.P.)
<i>The lazia rhodesii</i>	eye, lachrymal duct	Lucknow, Muzaffarnagar, Saharanpur, (U.P.) Muzaffarpur, Ranchi (Bihar) Sambalpur, Russolkund (Orissa) Dacca (Bengal)
<i>Trichouris ovis</i>	caecum	Lucknow (U.P.)
<i>Moniezia benedenti</i>	intestine	Moradabad (U.P.)
<i>Moniezia expansa</i>	intestine	Etawa, Gorakhpur, Lucknow, Muza- ffarnagar, Saharanpur (U. P.)
Hydatid cysts	liver	Purulia (Bihar)
<i>Echinococcus granulosus</i> (larval forms) cysts	lungs, liver	Bareilly, Gorakhpur, Kanpur, Morada- bad, Meerut, Muzaffarnagar, Luck- now, Saharanpur (U.P.) Ranchi, Muzaffarpur (Bihar) Calcutta (Bengal)
Beef measles	oesophagus, gullet	Lucknow (U. P.)

*New host record

TABLE II

New records of parasites in cattle

Name of the parasites	Location in host	Locality with new records
<i>Cotylophoron cotylophorum</i>	rumen	Barcilly, Gorakhpur, Kanpur, Lucknow, Meerut, Moradabad, Muzaffarnagar (U.P.) Muzaffarpur, Patna, Ranchi (Bihar) Barhampur, Sambalpur, Cuttack (Orissa) Begarhat, Barhambasia, Burdwan, Dacca, Faridpur, Jessore, Jeypore, Kharagpur, Kurseong, Khulna, Mymensingh, Midnapore, Tippera (Bengal) Dibrugarh, Dhubri, Gauhati, Jorhat, Silchar (Assam)
<i>Eurytrema pancreaticum</i> †	gall bladder	Darjeeling, Kalimpong (Bengal) Gauhati, Jorhat, Silchar (Assam)
<i>Fasciola gigantica</i>	liver	Agra, Bareilly, Gorakhpur, Lucknow, Meerut, Moradabad, Muzaffarnagar, Saharanpur (U. P.) Muzaffarpur, Patna, Ranchi (Bihar) Berhampur, Cuttack (Orissa) Burdwan, Darjeeling, Howrah, Rajshahi (Bengal) Dibrugarh, Gauhati, Jorhat (Assam)
* <i>Fasciola hepatica</i>	liver	Cuttack (Orissa)
<i>Fischoederius elongatus</i>	rumen	Lucknow, Muzaffarnagar (U. P.) Berhampur, Cuttack (Orissa) Barisal, Kharagpur (Bengal) Dibrugarh (Assam)
<i>Paramphistomum cervi</i>	gall bladder, liver, bile duct	Barcilly, Gorakhpur, Kanpur, Lucknow, Meerut, Moradabad, Muzaffarnagar, Saharanpur (U. P.) Patna, Ranchi (Bihar) Kharagpur, Khulna, Porejore (Bengal) Dibrugarh, Gauhati (Assam)
<i>Gastrothylax crumenifer</i>	rumen	Agra, Bareilly, Kanpur, Gorakhpur, Lucknow, Muzaffarnagar, Saharanpur, Shahjehanpur (U.P.) Arrah, Muzaffarpur, Patna, Ranchi, Samastipur, Kishanganj (Bihar)

†Rare record for India

TABLE II—(contd.)

New records of parasites in cattle

Name of the parasites	Location in host	Locality with new records
<i>Gastrothylax crumenifer</i>		Sambalpur, Berhampur, Cuttack (Orissa) Bachkergunj, Burdwan, Bhola, Bagerhat, Bogra, Barisal, Dacca, Faridpur, Ferozapore, Jessore, Kharagpur, Khulna, Howrah, Mymensingh, Midnapur, Porojore, Raiganj, Tippera (Bengal) Dibrugarh, Jorhat, Silehar (Assam)
<i>Fischoederius cobboldi</i>	rumen	Lucknow (U. P.) Barisal, Kharagpur, Tippera (Bengal) Dibrugarh (Assam)
<i>Ostertagia indicus</i>	rumen	Lucknow (U. P.)
<i>Homalophilus paloni</i>	caecum, colon	Lucknow (U. P.) Dibrugarh, Gauhati, Jorhat (Assam)
<i>Paramphistomum explanatum</i>	duodenum	Lucknow, Muzaffarnagar (U. P.) Dhubri, Silehar (Assam)
<i>Paramphistomum orthocodium</i>	rumen	Barilly, Lucknow, Moradabad (U. P.) Muzaffarpur (Bihar) Kharagpur, Porojore (Bengal)
<i>Schistosoma indicum</i> (eggs)	Portal veins, faeces	Lucknow (U. P.) Ranohi (Bihar) Sambalpur (Orissa) Jorhat (Bengal)
<i>Schistosoma bovis</i>	portal veins	Lucknow, Jhansi (U. P.)
* <i>Pseudodiscus collinsi</i>	intestine	Cuttack (Orissa)

*New host records

TABLE II—(contd.)
New records of parasites in cattle

Name of the parasites	Location in host	Locality with new records
* <i>Gastrodiscus aegyptiacus</i>	bile duct	Silchar (Assam)
<i>Ascaris vitulorum</i>	intestine	Gorakhpur (U. P.) Burdwan, Jaiganj, 24 Parganas (Bengal) Darbhanga (Bihar)
<i>Bunostomum trigonocephalum</i>	intestine	Lucknow (U. P.)
<i>Gongylonema pulchrum</i>	oesophagus	Lucknow (U. P.)
<i>Haemonchus contortus</i>	intestine, duodenum	Lucknow (U. P.) Cuttack (Orissa) Dacca, 24 Parganas, Raiganj (Bengal)
<i>Nematodirus filicollis</i>	intestine	Lucknow (U. P.)
<i>Oesophagostomum columbianum</i>	cæcum	Ranchi (Bihar) Jessore (Bengal)
<i>Oesophagostomum radiatum</i>	intestine	Lucknow (U. P.) Muzaffarpur (Bihar) Silchar (Assam)
<i>Mecistocirrus digitatus</i>	intestine	Bareilly, Lucknow, Meerut, Moradabad (U. P.) Patna, Samastipur (Bihar) Faridpur, Jessore (Bengal) Dibrugarh, Gauhati, Silchar (Assam)
<i>Parafilaria multipapillosa</i>	cutaneous hæmorrhage	Patna (Bihar)
<i>Setaria digitata</i>	peritoneal cavity	Muzaffarnagar (U. P.) Muzaffarpur (Bihar)
<i>Setaria labiatopapillosa</i>	peritoneal cavity	Agra, Bareilly, Etawah, Gorakhpur, Jhansi, Lucknow, Meerut, Morada- bad, Muzaffarnagar, Nainital, Saha- ranpur (U. P.)

* Indicates new host record

TABLE II—(contd.)
New records of parasites in cattle

Name of the parasites	Location in host	Locality with new records
<i>Setaria labiatopapillosa</i>		Muzaffarpur, Patna, Purulia, Ranchi (Bihar) Berhampur, Cuttack, Sambalpur (Orissa) Barisal, Bogra, Burdwan, Dacca, Faridpur, Manbhumi, Noakhali, 24 Parganas, Rajshahi (Bengal) Dibrugarh, Gauhati, Silchar (Assam)
<i>Thelazia rhodesii</i>	eye, lachrymal duct, inner canthus	Gorakhpur, Lucknow, Muzaffarnagar, Saharanpur (U. P.) Chapra, Ranchi, Muzaffarpur, Samastipur (Bihar) Cuttack, Sambalpur (Orissa) Dacca, Howrah, Kishoreganj, Pirojpur, Mymensingh, Bogra, Faridpur (Bengal) Dhubri, Jorhat, Silchar (Assam)
<i>Trichuris ovis</i>	caecum	Lucknow (U. P.) Khulna (Bengal) Silchar (Assam)
<i>Stephanofilaria assamensis</i>	hump sore, tail sore, yoke, foot	Chittagong, Dacca (Bengal) Dibrugarh, Gauhati (Assam) Berhampur, Cuttack (Orissa)
<i>Moniezia expansa</i>	intestine	Etawah, Lucknow, Muzaffarnagar (U.P.) Cuttack (Orissa) Chudanga, Kurseong (Bengal)
<i>Echinococcus granulosus</i> (cysts and larval forms)	livers, lungs	Baroilly, Gorakhpur, Kanpur, Lucknow, Meerut, Moradabad, Mussorie, Muzaffarnagar (U. P.) Ranchi, Purulia (Bihar) Cuttack, Sambalpur (Orissa) Dacca, Darjeeling, Calcutta, Howrah (Bengal) Dibrugarh, Gauhati, Jorhat, Silchar (Assam)
<i>Avitellina centripunctata</i>	intestine	Lucknow (U. P.) Cuttack (Orissa)
<i>Diphyllbothrium</i> sp.	intestine	Silchar (Assam)
<i>Hydatid</i> cysts	liver	Purulia, Samastipur (Bihar)

*Indicates new sites

TABLE III
New records of parasites recorded from sheep

Name of parasites	Location in host	Locality with new records
<i>Fasciola gigantica</i>	liver	Bareilly, Gonda, Gorakhpur, Lucknow, Meerut, Muzaffarnagar, Nainital, Saharanpur (U. P.), Berhampur, Cuttack (Orissa)
<i>Fischoederius cobboldi</i>	rumen	Lucknow (U. P.)
<i>Fischoederius elongatus</i>	rumen	Lucknow (U. P.) Berhampur, Cuttack (Orissa)
<i>Cotylophoron cotylophorum</i>	rumen	Bareilly, Gonda, Gorakhpur, Lucknow, Meerut, Muzaffarnagar, Nainital, Saharanpur, Moradabad (U. P.), Berhampur, Cuttack, Puri (Orissa) Ranchi (Bihar) Calcutta (Bengal) Dibrugarh (Assam)
<i>Gastrothylax crumenifer</i>	rumen	Bareilly, Gonda, Gorakhpur, Lucknow, Meerut, Muzaffarnagar, Saharanpur (U. P.) Arrah, Ranchi, Samastipur (Bihar). Berhampur, Cuttack, Puri (Orissa) Calcutta, Dacca (Bengal) Dibrugarh (Assam)
<i>Paramphistomum cervi</i>	rumen	Patna (Bihar)
<i>Paramphistomum explanatum</i>	rumen	Lucknow, Muzaffarnagar (U.P.)
<i>Paramphistomum orthococcium</i>	rumen	Lucknow, Muzaffarnagar (U.P.)
<i>Schistosoma indicum</i>	hepatic portal veins	Lucknow, Saharanpur (U.P.)
<i>Ascaris vitulorum</i>	intestine	Arrah (Bihar)
<i>Bunostomum trigonocephalum</i>	intestine	Bareilly, Meerut, Moradabad (U.P.) Ranchi (Bihar), Berhampur (Orissa) Calcutta, Dacca (Bengal) Dibrugarh (Assam)

TABLE III—(contd.)

New records of parasites recorded from sheep

Name of parasites	Location in host	Locality with new records
<i>Gaigeria pachyscelis</i>	intestine	Lucknow (U.P.) Berhampur, Cuttack (Orissa)
<i>Gongylonema pulchrum</i>	lungs	Saharanpur (U.P.) Sambalpur (Orissa)
<i>Haemonchus contortus</i>	intestine	Bareilly, Lucknow (U.P.) Berhampur, Cuttack (Orissa) Calcutta (Bengal)
<i>Oesophagostomum columbianum</i>	caecum, intestine	Bareilly, Gorakhpur, Lucknow, Muza- ffarnagar, Saharanpur (U.P.) Ranchi (Bihar) Berhampur, Cuttack (Orissa) Calcutta, Dacca, Darjeeling (Bengal) Dibrugarh (Assam)
<i>Oesophagostomum venulosum</i>	caecum	Lucknow (U.P.) Ranchi (Bihar)
<i>Oesophagostomum vitulorum</i>	intestine	Arrah (Bihar)
<i>Oesophagostomum asperum</i>	intestine	Lucknow, (U.P.) Berhampur (Orissa)
<i>Nematodirus filicollis</i>	intestine	Lucknow (U.P.)
<i>Strongyloides papillosus</i>	intestine	Lucknow (U.P.)
<i>Trichostrongylus colubriformi</i>	intestine	Lucknow (U.P.)
<i>Trichuris ovis</i>	caecum	Bareilly, Lucknow, Meerut, Moradabad, Muzaiffarnagar, Saharanpur (U.P.) Ranchi (Bihar) Berhampur, Cuttack (Orissa) Calcutta (Bengal) Dibrugarh (Assam)

TABLE III—(concl'd.)
New records of parasites recorded from sheep

Name of parasites	Location in host	Locality with new records
<i>Aoitellina centripunctata</i>	intestine	Bareilly, Etawah, Kanpur, Lucknow, Meerut, Moradabad, Muzaffanagar, Saharanpur (U.P.) Arrah, Muzaffarpur (Bihar) Berhampur (Orissa) Calcutta (Bengal)
<i>Aoitellina lahorea</i>	intestine	Lucknow (U.P.)
<i>Aoitellina tatia</i>	intestine	Lucknow (U.P.)
<i>Cysticercus tenuicollis</i>	abdominal cavity	Lucknow, Muzaffanagar, Saharanpur (U. P.) Muzaffarpur (Bihar) Cuttack (Orissa) Calcutta (Bengal)
<i>Echinococcus granulosus</i> (larval forms and cysts)	liver, lungs	Bareilly, Gorakhpur, Lucknow, Meerut, Moradabad, Muzaffanagar, Saharanpur (U. P.) Berhampur, Cuttack (Orissa)
<i>Moniezia benedeni</i>	intestine	Lucknow (U. P.)
<i>Moniezia denticulata</i>	intestine	Lucknow (U. P.)
<i>Moniezia expansa</i>	intestine	Bareilly, Etawah, Gonda, Gorakhpur, Lucknow, Meerut, Moradabad, Muzaffarnagar, Nainital, Saharanpur (U. P.) Arrah, Muzaffarpur (Bihar) Cuttack (Orissa) Calcutta (Bengal) Dibrugarh (Assam)
<i>Stilesia globipunctata</i>	intestine	Etawah, Gorakhpur, Lucknow, Muzaffarnagar, Saharanpur (U. P.) Arrah, Ranchi (Bihar) Berhampur, Cuttack, Puri (Orissa)] Calcutta (Bengal) Dibrugarh (Assam)
Measles and sunflowerlike cysts	inner lining of stomach	Lucknow (U. P.)

TABLE IV
New records of parasites recovered from goat

Name of parasites	Location in host	Locality with new records
<i>Cotylophoron cotylophorum</i>	rumen	Gorakhpur, Lucknow, Muzaffarnagar, Saharanpur (U. P.) Muzaffarpur, Ranchi (Bihar) Sambalpur Berhampur, Cuttack (Orissa) Burdwan, Calcutta, Chittagong, Dacca, Dinajpur, Howrah, Jaypore, Jalpaiguri, Jessore, Kharagpur, Raiganj, Rangpur, Tippera, (Bengal)
<i>Microcoelium</i> sp.	Bile duct	Dibrugarh, Dhubri, Gauhati, Jorhat, Silchar (Assam) Darjeeling (Bengal)
<i>Eurytrema pancreaticum</i>	liver	Darjeeling (Bengal) Dibrugarh, Gauhati, Jorhat, Shillong (Assam)
<i>Fasciola gigantica</i>	liver	Bareilly, Lucknow, Meerut, Moradabad (U. P.) Muzaffarpur (Bihar) Berhampur (Orissa) Chudanga, Dacca, Murshidabad (Bengal) Dibrugarh, Jorhat, Shillong (Assam)
<i>Fischoederius cobboldi</i>	rumen	Gonda (U. P.) Samastipur (Bihar) Dibrugarh, Shillong (Assam)
<i>Fischoederius elongatus</i>	rumen	Lucknow (U. P.) Jalpaiguri (Bengal) Gauhati (Assam)
<i>Gastrothylax crumenifer</i>	rumen	Gonda, Gorakhpur, Lucknow, Meerut, Muzaffarnagar, Saharanpur (U. P.) Sambalpur, Berhampur, Cuttack (Orissa) Muzaffarpur, Ranchi (Bihar) Barisal, Burdwan, Bagerhat, Bogra, Calcutta, Chittagong, Chuadanga, Dacca, Dinajpur, Jalpaiguri, Jessore, Mainapur, 24-Parganas, Raiganj (Bengal) Dhubri, Dibrugarh, Jorhat, Silchar, Gauhati (Assam)
* <i>Homalogaster paloninae</i>	caecum	Shillong (Assam)

* New host record.

TABLE IV—(contd.)
New records of parasites recovered from goat

Name of parasites	Location in host	Locality with new records
<i>Paramphistomum explanatum</i>	rumen	Lucknow (U. P.)
<i>Paramphistomum orthocoelium</i>	rumen	Lucknow, Moradabad, Muzaffarnagar (U. P.)
<i>Schistosoma indicum</i>	portal vein	Ranchi (Bihar)
<i>Bunostomum trigonocephalum</i>	intestine	Bareilly, Lucknow, Meerut, Moradabad (U. P.) Berhampur, Cuttack (Orissa) Ranchi (Bihar) Gauhati, Jorhat, Silchar (Assam)
<i>Gaigeria pachyscelis</i>	intestine	Lucknow (U. P.) Cuttack (Orissa)
<i>Gongylonema pulchrum</i>	rumen	Lucknow (U. P.) Cuttack, Sambalpur (Orissa)
<i>Haemonchus contortus</i>	abomasum	Bareilly, Lucknow, Meerut, Moradabad (U. P.) Muzaffarpur (Bihar) Cuttack, Sambalpur (Orissa) Calcutta, Jeypore (Bengal) Dibrugarh, Gauhati, Shillong (Assam)
<i>Nematodirus filicollis</i>	intestine	Lucknow (U. P.)
<i>Nematodirus</i> sp. (female only)	intestine	Lucknow (U. P.)
<i>Oesophagostomum asperum</i>	caecum	Lucknow (U. P.) Berhampur, Cuttack (Orissa)
<i>Oesophagostomum columbianum</i>	caecum, intestine	Bareilly, Gorakhpur, Lucknow, Muzaffarnagar, Saharanpur (U. P.) Muzaffarpur, Ranchi (Bihar) Sambalpur, Berhampur, Cuttack (Orissa) Barisal, Bhola, Calcutta, Chittagong, Dacca, Dinajpur, Jalpaiguri, Jeypore, Malda (Bengal) Dibrugarh, Gauhati, Jorhat, Shillong, Silchar (Assam)

TABLE IV—(contd.)

New records of parasites recovered from goat

Name of parasites	Location in host	Locality with new records
<i>Oesophagostomum venulosum</i>	caecum	Bogra (Bengal) Cuttack (Orissa) Lucknow (U. P.)
<i>Ostertagia circumcincta</i>	intestine, abomasum	Lucknow (U. P.)
<i>Setaria labiatopapillosa</i>	peritoneal cavity	Bogra (Bengal) Cuttack (Orissa) Lucknow (U. P.)
<i>Strongyloides papillosus</i>	intestine	Lucknow (U. P.)
<i>Trichostrongylus colubriformis</i>	intestine	Lucknow (U. P.) Khanapara (Assam)
<i>Trichuris ovis</i>	caecum	Barilly, Gorakhpur, Lucknow, Meerut, Moradabad, Muzaffarnagar, Saharanpur (U. P.) Ranchi (Bihar) Sambalpur, Berhampur, Cuttack (Orissa) Calcutta, Chittagong, Jalpaiguri, Jyepore, Malda (Bengal) Dibrugarh, Gauhati, Jorhat, Shillong, Silchar (Assam)
<i>Vesstrongylus pneumaticus</i>	lungs	Darjeeling (Bengal)
<i>Avitellina centripunctata</i>	intestine	Agra, Bareilly, Etawah, Gorakhpur, Lucknow, Meerut, Moradabad, Muzaffarnagar, Ranikhet, Saharanpur (U. P.) Muzaffarpur (Bihar) Sambalpur, Berhampur, Cuttack (Orissa)
<i>Avitellina lahorea</i>	intestine	Lucknow, Ranikhet (U. P.)
<i>Avitellina ratia</i>	intestine	Lucknow, Ranikhet (U. P.)
<i>Avitellina sudanea</i>	intestine	Mussoorie, Ranikhet (U. P.)
<i>Avitellina woodlandi</i>	intestine	Ranikhet (U. P.)
<i>Oeuvurus cerebitalis</i>	brain	Jorhat (Assam)

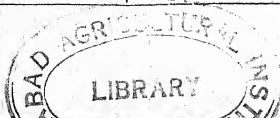


TABLE IV—(concl'd.)
New records of parasites recovered from goat

Name of parasites	Location in host	Locality with new records
<i>Cysticercus tennicollis</i>	abdominal cavity	Lucknow, Muzaffarnagar, Saharanpur (U. P.) Muzaffarpur, Patna (Bihar) Berhampur, Cuttack (Orissa) Calcutta (Bengal) Dibrugarh, Gauhati, Jorhat, Shillong (Assam)
<i>Echinococcus</i> cysts (Hydatid)	liver, lungs	Bareilly, Lucknow, Meerut, Moradabad, Mussoorie, Muzaffarnagar, Nainital, Saharanpur (U. P.) Calcutta, Darjeeling, Kharagpur (Bengal) Purnea (Bihar)
<i>Echinococcus granulosus</i> (larval forms)	lungs, liver	Nainital (U. P.) Berhampur, Cuttack (Orissa) Calcutta, Kharagpur (Bengal)
<i>Moniezia benedini</i>	intestine	Cuttack (Orissa) Diamond Harbour (Bengal)
<i>Moniezia denticulata</i>	intestine	Lucknow (U. P.)
<i>Moniezia expansa</i>	intestine	Agra, Bareilly, Etawah, Gorakhpur, Kanpur, Lucknow, Meerut, Moradabad, Muzaffarnagar, Saharanpur (U. P.) Muzaffarpur, Samastipur, Sasaram, Patna (Bihar) Berhampur, Cuttack (Orissa) Alipur Duar, Cooch Behar, Calcutta, Jalpaiguri, Rangpur (Bengal) Dibrugarh, Gauhati, Jorhat, Silchar (Assam)
<i>Taenia galgeri</i> (larval forms)	intestine	Tippora (Bengal)
<i>Taenia hydatigena</i> (larva)	intestine	Lucknow, Bareilly, Meerut, Moradabad, (U. P.) Samastipur (Bihar) Rajshahi (Bengal)

Besides these, there were several recoveries of the parasites reported from other animals, domestic and wild, that came under observation during the course of our investigations. They are listed in Table IV-A. Some of these were sent for identification by the Directors of the provinces under investigation.

TABLE IV-A
Parasites recovered from other animals

Host	Parasites	Location in host	Locality
Elephant	<i>Fasciola jacksoni</i>	liver	Gauhati (Assam)
	<i>Gastrodiscus secundus</i>	intestine	Jeypore (Orissa)
	<i>Pseudodiscus collinsi</i>	stomach, intestine	Muzaffarpur (Bihar) eggs at Gauhati
	<i>Pseudodiscus kaurkessii</i>	intestine	Muzaffarpur, Assam
	<i>Choniangium epistomum</i>	faeces	Muzaffarpur, Assam
	<i>Murshidia murshidia</i>	faeces	Aska (Orissa) Muzaffarpur, Assam
	<i>Quilonia renniei</i>	intestine	Assam
	<i>Sclerostome</i> eggs	faeces	Gauhati (Assam)
Cat	<i>Chlamydonema praepatialis</i>	stomach	Burdwan (Bengal)
	<i>Taenia pisiformis</i>	intestine	Puri (Orissa)
Lion's cub	<i>Texascaris leonina</i>	intestine	Jeypore (Orissa)
Horse	<i>Pseudodiscus collinsi</i>	intestine	Patna, Chapra (Bihar)
	<i>Habronema megastoma</i>	intestine	Lucknow (U. P.) Belgachia (Bengal)
	<i>Habronema muscae</i>	stomach	Patna (Bihar)
	<i>Oxyuris equi</i>	intestine	Muzaffarpur (Bihar) Chapra (Bihar) Jalpaiguri (Bengal)
	<i>Setaria equina</i>	eye	Muzaffarpur, Chapra, Purnea (Bihar) Mymensingh (Bengal)

TABLE IVA—(contd.)

Host	Parasites	Location in host	Locality
Horse	<i>Strongylus edentata</i> (Alfortia)	intestine	Patna (Bihar)
	<i>Strongylus vulgaris</i>	intestine	Belgachia (Bengal)
	<i>Thelazia lachrymalis</i>	eye	Dacca (Bengal)
	<i>Trichonema catinatum</i>	intestine	Patna (Bihar)
Mule	<i>Pseudodiscus collinsi</i>	intestine	Lucknow (U. P.)
Dog	<i>Echinococcus granulosus</i>	intestine	Lucknow (U. P.)
	<i>Dipylidium caninum</i>	intestine	Lucknow, (U. P.) Muzaffarpur (Bihar) Burdwan, Nadia, Siliguri (Bengal)
	<i>Tenia pisiformis</i>	intestine	Muzaffarpur (Bihar)
	<i>Ancylostoma caninum</i>	intestine	Lucknow (U.P.), Muzaffarpur (Bihar)
	<i>Dirofilaria immitis</i>	heart	Perojpur
	<i>Dirofilaria sp.</i> (female)	thigh muscles	Patna (Bihar)
	<i>Spirocera sanguinolenta</i>	stomach	Calcutta, Lucknow
	<i>Toxocara canis</i>	stomach, intestine	Barisal, Burdwan, Diamond Harbour, Kishanganj, Muzaffarpur.
Pig	<i>Fasciolopsis buski</i>	intestine	Calcutta, Darjeeling
	<i>Gastrodiscus aegyptiacus</i>	intestine	Calcutta
	<i>Gastrodiscoides hominis</i>	intestine	Darjeeling
	<i>Arduena strongylina</i>	stomach	Calcutta
	<i>Ascaris lumbricoides</i>	intestine	Darjeeling, Jalpaiguri, Perojpur
	<i>Cruzia orientalis</i>	intestine	Calcutta
	<i>Metastrongylus elongatus</i>	lungs	Calcutta
	<i>Oesophagostomum dentatum</i>	intestine	Calcutta

TABLE IVA—(contd.)

Host	Parasites	Location in host	Locality
Wild boar	<i>Moniezia benedeni</i>	intestine	Uttar Pradesh
	<i>Moniezia expansa</i>	intestine	Uttar Pradesh
	<i>Pseudanoplocephalus</i> sp.	intestine	Uttar Pradesh
Giraffe	<i>Trichuris ovis</i>	intestine	Calcutta
Man	<i>Gastrodiscoides hominis</i>	intestine	Gauhati
	<i>Fasciolopsis buski</i>	intestine	Gauhati
	* <i>Eristalis</i> larvae	faeces	Calcutta
Fowl	<i>Hymenolepis rustica</i>	intestine	Purnea (Bihar)
	<i>Railletina tetragona</i>	intestine	Barisal, Lucknow, Patna, Muzafarpur
	<i>Railletina</i> sp. (non-gravid)	intestine	Alipur Duar, Porojpur, Muzafarpur
	<i>Ascaridia galli</i>	intestine	Calcutta, Lucknow, Sambalpur
	<i>Ascaridia perspiculum</i>	intestine	Champaran, Purnea
	<i>Ascaridia</i> sp. (female)	caecum	Patna
	<i>Heterakis gallinae</i>	caecum	Belgachia, Patna
	<i>Heterakis indica</i>	intestine	Lucknow
Fish	<i>Caryophyllus indicus</i>	intestine	Bogra (Bengal)
Ptyas ptyas	<i>Kalicephalus indicus</i>	stomach	Lucknow

*Indicates new record in India for the first time.

It would, thus, appear that in giving the above new records of the occurrence of the helminth parasites in domesticated animals in the area under review, the following points stand out prominently. *Homalogaster paloniæ*, a common parasite of the buffaloes and cattle has been recovered also from goats in Shillong (Assam). *Gastrodiscus aegyptiacus* and *Pseudodiscus collinsi*, two common parasites of horses are being reported for the first time from cattle in India. This occurrence is unique, as it is generally believed that none of the parasites of horses are found in other domestic animals and man, and *vice versa* in spite of their close association from times immemorial and this falsifies the universally accepted principle.

Fasciola hepatica, a common parasite of cattle, sheep and goats in Europe and other Western countries, is of rare occurrence in India, a single specimen being recovered from the liver of cattle in Cuttack (Orissa). The form generally found in India is *Fasciola gigantica* originally reported from Africa by Cobbold [1855]. Kemp [1919] recorded its occurrence for the first time in Seistan (Asia) from sheep. He, in his description, gave the distinguishing features of this species as against *F. hepatica*. Varma [1953], without reference to this work, assigned this Asiatic form under a new designation, *Fasciola indica*, basing his conclusions on the examination of the material collected by him from India from goats and buffaloes and also from the materials made available to him at the London School of Hygiene and Tropical Medicine. He distinguished this new form mainly on the nature of the cuticular scales, size of the eggs and the presence of a post-buccal ring. If his contention of creating a new species is accepted, the form reported in this survey as *Fasciola gigantica* would naturally fall under *F. indica*. One point which has been overlooked by either of the two observers who have described this form under two different names for the form recovered by them respectively is the presence of several rows of spines on the cirrus. The cirrus is always armed in the Indian species.

A new genus, *Olveria*, with two species has also been reported and described from cattle and buffaloes in India. *Paramphistomum gotoi*, a rare parasite reported so far from the Far East by Fukui [1926] and later by Dawes [1936] from Malaya, has also been recovered from the buffaloes in Lucknow on several occasions and appears to be fairly common in this country.

MULTIPLE INFECTIONS

It is worthwhile to mention that during the course of our survey of helminth parasites, several cases of multiple infections, i.e. the occurrence of two or more species of worms infesting the same organ of the same individual host, were observed. This multiplicity of parasites infecting the same organ in the body of the same host further undermines the health of the host and deserves special consideration. The details of such cases of multiple infections of helminths in the ruminants are given below :

1. *Fasciola gigantica* occurring along with :

- (a) *Paramphistomum cervi*—in the liver of cattle and buffaloes
- (b) *Schistosoma indicum*—in the liver of buffaloes
- (c) *S. bovis*—in the liver of cattle

2. *Paramphistomum orthocoelium*—occurring with :
 - (a) *Cotylophoron cotylophorum*—in the stomach of cattle, buffaloes, sheep and goats
 - (b) *Gastrothylax crumenifer*—in the rumen of cattle, buffaloes, sheep and goats
 - (c) *Gastrothylax crumenifer*, *Olvieria indica*, *Cotylophoron cotylophorum*—in the rumen of buffaloes
 - (d) *Olvieria indica*, *O. boei*, *Paramphistomum gotoi*, *Fischocodermis elongatus*, *G. crumenifer* and *C. cotylophorum*—in the rumen of buffaloes
 - (e) *O. indica*, *P. gotoi*, *F. elongatus*, *F. cobboldi*, *Carmyerius spatiosus*, *C. cotylophorum* and *G. crumenifer*—in the rumen of buffaloes
3. *Paramphistomum explanatum*—occurring with :
 - (a) *F. elongatus*, *F. cobboldi*, *C. cotylophorum* and
 - (b) *O. indica*, *G. crumenifer*, *P. orthocoelium*, and *C. cotylophorum*—in the rumen of buffaloes
4. *Olvieria indica*—occurring with :
 - (a) as in 2(c), (d), (e) and 3(b)
5. *P. gotoi*—occurring with :
 - (a) as in 2(d) and 2(e)
 - (b) *P. explanatum*, *F. elongatus*, *F. cobboldi* and *C. cotylophorum*—in the rumen of buffaloes
 - (c) *G. crumenifer*, *P. orthocoelium*, *F. elongatus*, *Olvieria boei* and *C. cotylophorum*—in the rumen of buffaloes
6. *Cotylophoron cotylophorum*—occurring with :
 - (a) *G. crumenifer*—in the rumen of buffaloes, cattle, sheep and goats
 - (b) *F. elongatus*—in the rumen of buffaloes and sheep
 - (c) as in 2(a), (c), (d), (e), 3(a), (b), 5(b) and (c)
7. *Bunostomum trigonocephalum*—occurring with :
 - (a) *Gaigeria pachyscelis*—in the intestine of sheep and goats
 - (b) *Gaigeria pachyscelis* and *Strongyloides papillosus*—in the intestine of sheep
 - (c) *Strongyloides papillosus*—in the intestine of sheep and goats
 - (d) *Trichostrongylus colubriformis*—in the intestine of sheep and goats
 - (e) *Oesophagostomum columbianum* and *O. venulosum*—in the intestine of sheep and goats
8. *Haemonchus contortus*—occurring with :
 - (a) *Stilesia globipunctata*—in the duodenum of goats and sheep
9. *Trichouris ovis*—occurring with :
 - (a) *O. columbianum*—in the caecum of sheep and goats

10. *Gongylonema pulchrum*—occurring with :
 - (a) *P. orthocoelium*, *G. crumenifer*, *C. cotylophorum*, *F. elongatus* and other amphistomes—in the stomach of buffalo
11. *Stilesia globipunctata*—occurring with :
 - (a) *Avitellina centripunctata*—in the intestine of sheep and goats.
 - (b) *A. centripunctata*, *Moniezia expansa*, and *M. benedeni*—in the intestine of sheep and goats.
12. *Gongylonema pulchrum*—occurring with :
 - (a) *P. orthocoelium*, *G. crumenifer*, *C. cotylophorum*, *F. elongatus* and other amphistomes—in the stomach of buffaloes
13. *Stilesia globipunctata*—occurring with :
 - (a) *Avitellina centripunctata*—in the intestine of sheep and goats
 - (b) *A. centripunctata*, *Moniezia expansa*, and *M. benedeni*—in the intestine of sheep and goats

INCIDENCE AND INTENSITY OF INFECTION

A study of the incidence and intensity of infections in cattle, buffaloes, sheep and goats was made for two consecutive years i.e. 1939-1941. For this purpose one animal of each type was selected daily, except on holidays and the days on which no slaughtering of animals takes place. This gives us variable number of animals each month. The work was restricted to the slaughter-houses at Lucknow, where animals are brought from the surrounding area for slaughtering. The method followed to determine incidence and intensity is that followed by Fenwick [1937] in Professor Tattersall's laboratory at Cardiff. The same method was subsequently followed by Swales [1940] at the Institute of Parasitology, McGill University. The incidence of infection is determined on the basis of the proportion of the infected animals to the total number of animals examined at random; while the intensity of infection has been calculated as an average load on the basis of the infected animals only and is thus in line with the statistical work done at other centres. The results are embodied in Tables V, VI, VII, and VIII. Each Table shows the names of the parasites, followed by the monthly determinations arranged under separate columns. The columns 1, 2, and 3 show the incidence of infections and columns 4, and 5 show the intensity of infection giving an average load per animal.

At a later stage, while studying the incidence and intensity of infection of *Oliveria indica* [Thapar and Sinha 1945, Tandon 1951] in buffaloes only (cattles are not slaughtered under orders of the State Government in U. P.) at Lucknow, advantage was taken to record the incidence and intensity of infections of two other amphistomes, *Oliveria bovis* [Tandon 1951] and *Paramphistomum gotoi*, [Tandon 1955] recovered from the buffaloes and the results are reported in Table IX. This indicates that all these three species are fairly common in this country at any rate, in Lucknow and its environments from where the animals are brought for slaughtering.

TABLE V
Statement showing incidence and intensity of infection in buffaloes

Name of parasites	April, 1939						May, 1939						June, 1939					
	No. examined	No. infected	per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal		No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal		No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	
<i>Paramphistomum cervi</i>	19	17	89.5	1,712	100		17	16	94.1	1,779	111		19	19	100	8,519	185	
<i>Paramphistomum explanatum</i>	19	..	..	..	..		17	..	..	..	..		19	..	..	..	..
<i>Paramphistomum orthocellum</i>	19	3	15.8	108	36		17	..	..	..	..		19	..	..	..	..
<i>Codjophoron colyphorum</i>	19	3	15.8	239	79		17	..	..	..	..		19	1	5.2	5	5	
<i>Ga. strobilaz erumenifer</i>	19	19	100	11,853	624		17	17	100	7,680	451		19	19	100	7,548	397	
<i>Fischeriaria elongatus</i>	19	..	..	..	..		17	..	..	..	..		19	..	..	..	..
<i>Fasciola gigantica</i>	19	15	79	202	13		17	13	76.5	156	12		19	13	68.4	97	7	
<i>Mecistocirrum digitatus</i>	19	2	10.5	156	78		17	..	..	..	..		19	4	21	19	5	
<i>Staria labiatopapillosa</i>	19	15	79	60	4		17	10	59	50	5		19	15	79	159	11	

TABLE V—(contd.)
Statement showing incidence and intensity of infection in buffaloes

Name of Parasites	July, 1959					August, 1959					September, 1959				
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal
<i>Paraphistomum cervi</i>	16	16	100	1,780	111	20	20	100	5,082	254	16	15	93.7	3,859	257
<i>Paramphistomum exanthum</i>	16	..	..	..	..	20	1	5	59	59	16	..	..	..	..
<i>Paramphistomum orthocollum</i>	16	1	6.2	22	22	20	4	20	580	145	16	1	6.2	485	455
<i>Colasporeon setiglorum</i>	16	3	18.7	107	36	20	7	35	617	88	16	9	56.2	1,052	117
<i>Gastrophilus cruentifur</i>	16	16	100	12,884	805	20	19	95	14,379	757	16	15	93.7	20,038	1,386
<i>Fasciolaria elongatus</i>	16	..	..	..	..	20	..	..	..	..	16	1	6.2	867	567
<i>Fasciola gigantica</i>	16	10	62.5	107	10	20	17	85	189	11	16	13	81.2	246	19
<i>Microsternus digitatus</i>	16	3	18.7	17	6	20	1	5	10	10	16	1	6.2	11	11
<i>Sarcia labiatopapillosa</i>	16	11	68.7	23	2	20	17	85	56	3	16	15	93.7	48	3

TABLE V—(contd.)
Statement showing incidence and intensity of infection in buffaloes

Name of parasites	October, 1939						November, 1939						December, 1939					
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	No. examined	No. infected	Per cent of infection
<i>Paramphistomum cervi</i>	20	14	70	1,739	124	20	20	100	3,017	196	17	17	100	5,296	311	17	17	100
<i>Paramphistomum explanatum</i>	20	..	..	..	..	20	..	..	..	..	17	1	5.9	20	20	17	1	5.9
<i>Paramphistomum orthocotium</i>	20	1	5	81	81	20	..	..	..	..	17	..	..	..	..	17	..	..
<i>Oedophora scoloporum</i>	20	4	20	563	141	20	8	40	198	19	17	7	41.2	321	46	17	7	41.2
<i>Gastrophilus crumenifer</i>	20	20	100	15,542	777	20	20	100	10,266	513	17	17	100	11,749	682	17	17	100
<i>Fischodorus elongatus</i>	20	1	5	42	42	20	..	..	..	..	17	..	..	..	..	17	..	..
<i>Fasciola gigantica</i>	20	14	70	121	9	20	19	95	243	13	17	16	94.1	439	27	17	16	94.1
<i>Mecistocirrus digitatus</i>	20	1	5	5	5	20	..	..	..	..	17	..	..	..	..	17	..	..
<i>Sauria labiotropilosa</i>	20	10	50	34	2	20	16	80	47	3	17	13	76.5	35	3	17	13	76.5

TABLE V—(contd.)
Statement showing incidence and intensity of infection in buffaloes

Name of parasite	January, 1940					February, 1940					March, 1940				
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the	Average load per animal
<i>Paramphistomum cervi</i>	17	16	94.1	4,656	293	18	17	94.4	4,542	257	17	17	100	5,680	331
<i>Paramphistomum explanatum</i>	17	..	..	..	..	18	..	..	..	..	17	2	11.7	256	128
<i>Paramphistomum orthocodium</i>	17	..	..	..	..	18	..	..	..	..	17	..	..	..	..
<i>Colyphoron caplophorum</i>	17	6	35.3	788	181	18	6	33.3	466	78	17	3	17.6	585	195
<i>Gastrodiplos crumenifer</i>	17	17	100	9,803	565	18	18	100	16,077	893	17	17	100	17,148	1,008
<i>Ptychodactylus longius</i>	17	..	..	..	..	18	..	..	..	..	17	..	..	..	..
<i>Fasciola gigantica</i>	17	14	82.5	329	23	18	15	83.3	445	30	17	16	94.1	399	25
<i>Metasticturus dignatus</i>	17	..	..	..	..	18	..	..	..	..	17	..	..	..	..
<i>Scleria laticapillata</i>	17	14	82.5	90	6	18	18	100	194	11	17	17	100	232	14

TABLE V—(contd.)
Statement showing incidence and intensity of infection in buffaloes

Name of parasites	April, 1940					May, 1940					June, 1940				
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection
<i>P. cervi</i>	20	20	100	6,508	325	21	21	100-0	5,802	276	20	20	100	3,462	173
<i>Gastrothylax crumenifer</i>	20	20	100	22,203	1,113	21	21	100-0	24,612	1,172	20	20	100	12,765	638
<i>Fischeriella elongatus</i>	20	..	..	..	..	21	..	..	..	..	20	..	..	..	..
<i>Coelophorus colyphorum</i>	20	4	20	1,041	260	21	6	28-6	673	112	20	5	25	450	90
<i>P. orthocotum</i>	20	..	..	..	..	21	..	..	..	..	20	..	..	..	..
<i>Fasciola gigantica</i>	20	15	60	467	31	21	20	95-2	460	23	20	20	100	415	21
<i>Mecistocirrus digitatus</i>	20	..	..	..	..	21	..	..	..	..	20	..	..	..	..
<i>Setaria latitapapillosa</i>	20	20	100	243	12	21	21	100-0	219	10	20	20	100	140	7
<i>Thelazia rhodesii</i>	20	..	..	..	..	21	..	..	..	..	20	..	..	..	..
<i>Oesophagostomum columbianum</i>	20	..	..	..	..	21	..	..	..	..	20	..	..	..	..
<i>Monilia organisa</i>	20	..	..	..	..	21	..	..	..	..	20	..	..	..	..
<i>P. explanatum</i>	20	..	..	..	..	..	216	..	..	..	20	..	..	..	..

TABLE V—(contd.)
Statement showing incidence and intensity of infection in buffaloes

Name of Parasites	July, 1940					August, 1940					September, 1940				
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection
<i>F. cervi</i>	20	19	95	4,416	232	20	20	100	6,400	322	20	20	100	6,295	314
<i>Gastrothylax crumenifer</i>	20	20	100	19,842	992	20	19	95	37,914	1,995	20	20	100	33,412	1,659
<i>F. theileri</i>	20	..	..	..	..	20	2	10	2,471	1,235	20	..	..	..	..
<i>Cooperia coloporum</i>	20	8	40	1,146	143	20	13	65	1,734	133	20	7	35	279	40
<i>F. orthocentum</i>	20	..	..	..	..	20	..	..	..	..	20	..	..	..	..
<i>Fasciola gigantica</i>	20	16	80	183	12	20	18	90	402	22	20	20	100	1,613	81
<i>Metasternus digitatus</i>	20	1	5	15	15	20	..	..	..	..	20	..	..	..	..
<i>Sclero habitopogoniflora</i>	20	20	100	167	8	20	20	100	103	10	20	20	100	129	6
<i>Thalassia rhodesii</i>	20	..	..	..	..	20	..	..	..	..	20	..	..	..	..
<i>Oesophagostomum columbianum</i>	20	..	..	..	..	20	..	..	..	..	20	..	..	..	..
<i>Monilia caprina</i>	20	..	..	..	..	20	..	..	..	..	20	..	..	..	..
<i>P. explanatum</i>	20	4	20	255	71	20	1	5	22	22	20	..	..	..	..

TABLE V—(contd.)
Statement showing incidence and intensity of infection in buffaloes

Name of Parasites	October, 1940					November, 1940					December, 1940				
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per
<i>P. terri</i>	18	18	100-0	4,048	225	19	18	94.7	3,607	200	19	18	94.7	4,373	243
<i>Gastrothylax crumenifer</i>	18	18	100-0	28,641	1,591	19	18	94.7	23,751	1,320	19	17	89.4	15,934	839
<i>Fiachoderius elongatus</i>	18	..	..	..	..	19	..	..	..	..	19	..	..	..	..
<i>Cyclophorus corylophorus</i>	18	10	55-6	736	78	19	9	47.4	1,547	150	19	6	31.6	490	81
<i>P. orthocellum</i>	18	..	..	..	..	10	2	10-5	238	119	19	..	..	..	..
<i>Fasciola gigantica</i>	18	17	94.4	1,178	69	19	18	70-0	555	39	10	14	73.7	270	19
<i>Metastocirus digitatus</i>	18	..	..	..	..	18	..	..	..	..	19	1	5.3	5	5
<i>Stenaria laetiocephala</i>	18	18	100-0	103	6	19	19	100-0	145	7	19	16	84.2	118	7
<i>Thelazia rhodesii</i>	18	..	..	..	..	19	..	..	..	..	19	..	..	..	..
<i>Oesophagostomum columbianum</i>	18	..	..	..	..	19	..	..	..	..	19	..	..	..	..
<i>Moniezia expansa</i>	18	..	..	..	..	19	..	..	..	..	19	..	..	..	..
<i>P. argyranatum</i>	18	..	..	..	..	19	1	5.3	816	816	19	1	5.3	91	91

TABLE V—(conold.)
Statement showing incidence and intensity of infection in buffaloes

Name of parasites	January, 1941					February, 1941					March, 1941				
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per
<i>P. cori</i>	19	16	84.2	3,295	206	15	12	80.0	2,041	170	19	17	89.4	2,811	165
<i>Gastrophilus cruentifer</i>	19	17	89.4	18,827	990	15	13	86.7	15,501	1,192	19	19	100.0	25,971	1,382
<i>Fischeriella elongatus</i>	19	..	..	..	..	15	..	..	..	..	19	..	..	..	..
<i>Corytophoron corytophorum</i>	19	6	31.6	2,354	389	15	6	40.0	431	72	19	9	47.4	1,519	169
<i>P. orthocentrum</i>	19	1	5.3	70	70	15	..	..	..	..	19	..	..	..	..
<i>Faciola gigantea</i>	19	11	57.9	335	30	15	8	53.3	126	16	19	11	57.9	303	27
<i>Melittosyrus eliphatius</i>	19	..	..	..	..	15	..	..	..	..	19	1	5.3	11	11
<i>Stertia tabulocapillata</i>	19	18	94.7	136	7	15	14	93.3	105	7	19	18	94.7	185	10
<i>Thelazia rhodesii</i>	19	..	..	..	..	15	..	..	..	..	19	..	..	..	..
<i>Oesophagostomum columbianum</i>	19	..	..	..	..	15	..	..	..	..	19	..	..	..	..
<i>Monileia expansa</i>	19	..	..	..	..	15	..	..	..	..	19	..	..	..	..
<i>P. explanatum</i>	19	2	10.5	153	79	15	..	..	..	..	19	..	..	..	..

TABLE VI
Statement showing incidence and intensity of infection in cattle

Name of parasites	April, 1939					May, 1939					June, 1939				
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal
<i>Paramphistomum cervi</i>	6	3	50	577	95	17	17	100	1,993	117	20	20	100	3,685	134
<i>Paramphistomum explanatum</i>	6	..	..	..	..	17	..	..	..	..	20	..	..	..	..
<i>Paramphistomum orthocotum</i>	6	3	50	56	19	17	..	..	..	..	20	..	..	..	..
<i>Cotylaphoren colylophorum</i>	6	3	50	188	63	17	7	41.2	666	95	20	9	45	826	92
<i>Gastrophilus crumifer</i>	6	4	66.6	1,770	442	17	17	100	7,120	419	20	20	100	8,095	405
<i>Fasciola douglasi</i>	6	3	50	179	59	17	1	6	9	9	20	..	..	..	..
<i>Fasciola gigantica</i>	6	..	..	..	..	17	15	88.2	105	13	20	11	70	127	9
<i>Eurostomum trigonocephalum</i>	6	4	66.6	32	8	17	..	..	..	..	20	..	..	..	..
<i>Oesophagostomum radiatum</i>	6	..	..	..	..	17	..	..	..	..	20	..	..	..	..
<i>Mesitocotylus digitatus</i>	6	..	..	..	..	17	9	53	00	7	20	12	60	54	4
<i>Staria labiatogapillora</i>	6	2	33.3	6	3	17	15	70.6	39	3	20	15	75	14	3
<i>Thelazia rhodesii</i>	6	1	16.6	1	2	17	5	17.6	4	1	20	6	30	8	1

NOTE.—In the estimation of average load per infection fractions of one-half or less have been omitted and those more than one-half counted as one.

TABLE VI—(contd.)
Statement showing incidence and intensity of infection in cattle

Name of parasites	July, 1956						August, 1956						September, 1956					
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average animal load per		No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average animal load per		No. examined	No. infected	Per cent of infection	Total No. of parasites infected animals	Average animal load per	
<i>Paramphistomum cervi</i>	18	18	100	2,102	117		19	18	94.7	4,603	256		14	14	100	2,599	185	
<i>Paramphistomum crispum</i>	18	..	..	..	..		10	1	5.2	2	2		14	..	..	..	..
<i>Paramphistomum orthocellum</i>	18	..	..	..	..		10	1	5.2	5	5		14	..	..	..	..
<i>Oxyphorus colophorus</i>	18	7	38.9	1,120	161		10	11	57.9	901	82		14	4	28.5	328	82	
<i>Gastrodylus ermanni</i>	18	18	100	8,446	469		19	19	100	14,015	738		14	14	100	14,745	1,053	
<i>Fasciolaria elongata</i>	18	..	..	..	..		19	..	..	..	..		14	..	..	..	..
<i>Fasciola gigantica</i>	18	17	94.8	167	10		19	19	100	223	12		14	14	100	121	15	
<i>Bursosoma trigonocephalum</i>	18	..	..	..	..		19	..	..	..	..		14	1	7.1	7	7	
<i>Oesophagostomum radiatum</i>	18	..	..	..	..		19	..	..	..	..		14	1	7.1	11	11	
<i>Meisodictyus albidus</i>	18	5	27.5	14	3		19	10	52.6	56	5		14	2	14.3	30	15	
<i>Suaria labidopygilla</i>	18	12	66.6	34	3		19	17	89.5	61	4		14	10	71.4	37	4	
<i>Thelazia rhodesii</i>	18	6	33.3	10	2		19	2	10.5	3	1		14	..	..	..	..

NOTE.—In the calculation of average load per infection fractions of one-half or less have been omitted and those more than one-half counted as one.

TABLE VI—(contd.)
Statement showing incidence and intensity of infection in cattle

Name of Parasites	October, 1939						November, 1939						December, 1939				
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal		No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal		No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal
<i>Paramphistomum cervi</i>	17	10	58.8	1,477	148		15	14	93.3	2,846	203		16	16	100	3,175	198
<i>Paramphistomum caproni</i>	17	..	..	..	..		15	..	..	..	..		16	..	..	..	..
<i>Paramphistomum orthocellum</i>	17	..	..	..	..		15	..	..	..	..		16	..	..	..	..
<i>Cotylephoron captophorum</i>	17	5	29.4	240	48		15	4	26.7	185	34		16	5	31.2	344	69
<i>Gastrothylax crumenifer</i>	17	14	82.5	10,051	718		15	15	100	5,512	387		16	16	100	9,304	582
<i>Fascioloides elongatus</i>	17	..	..	..	..		15	2	13.3	80	15		16	1	6.2	52	52
<i>Fasciola gigantica</i>	17	7	42.1	46	7		15	14	93.3	174	12		16	12	75	329	21
<i>Bunostomum trigonocephalum</i>	17	7	..	..	..		15	..	6.6	11	11		16	..	..	..	..
<i>Oesophagostomum radiatum</i>	17	..	..	..	..		15	1	6.6	6	6		16	1	6.2	3	3
<i>Metastomum digitatus</i>	17	1	5.9	2	2		15	3	20	13	4		16	4	25	29	7
<i>Scer in labiotopopillosa</i>	17	3	17.6	8	3		15	10	66.6	55	10		16	15	93.9	94	6
<i>Thelazia rhodesii</i>	17	..	..	..	..		15	..	..	..	..		16	..	..	..	..

NOTE.—In the calculation of average load per infection of one-half or less have been omitted and those more than one-half counted as one.

TABLE VI—(contd.)
Statement showing incidence and intensity of infection in cattle

Name of parasites	January, 1940					February, 1940					March, 1940				
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal
<i>Paraphistomonas cervi</i>	12	12	100	2,207	191	13	13	100	2,333	105	12	12	100	2,731	228
<i>Paraphistomonas eximianus</i>	12	..	..	..	..	13	..	..	..	..	12	..	..	..	..
<i>Paraphistomonas orthocostum</i>	12	..	..	..	..	13	..	..	..	..	12	..	..	..	..
<i>Oxylophorus colidophorum</i>	12	5	41.7	633	127	13	5	38.5	452	90	12	3	25	274	91
<i>Gastrothylax crassifur</i>	12	12	100	5,431	453	13	13	100	4,758	368	12	12	100	6,121	510
<i>Fischederius douglensis</i>	12	..	..	..	..	13	..	..	..	..	12	..	..	..	..
<i>Fasciola gigantica</i>	12	12	100	150	12	13	13	100	139	11	12	12	100	113	9
<i>Bunostomum trilonocophalum</i>	12	..	..	..	..	13	..	..	..	..	12	..	..	..	..
<i>Oesophagostomum radiatum</i>	12	..	..	..	..	13	..	..	..	..	12	..	..	..	..
<i>Mecistoctrus digitatus</i>	12	..	..	..	..	13	..	..	..	..	12	..	..	..	..
<i>Stomoxys calcitrans</i>	12	12	100	103	9	13	13	100	113	9	12	11	91.7	90	8
<i>Thelazia rhodesii</i>	12	..	..	..	..	13	..	..	..	..	12	..	..	..	..

NOTE. In the calculation of average load per infection fractions of one-half or less have been omitted and those more than one-half counted as one.

TABLE VI—(contd.)
Statement showing incidence and intensity of infection in cattle

Name of parasites	April, 1940					May, 1940					June, 1940				
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per
<i>P. cervi</i>	14	14	100.0	2,317	201	15	15	100.0	3,141	200	14	14	100.0	2,755	197
<i>Gastrothylax erumenifer</i>	14	14	100.0	6,180	441	15	15	100.0	8,993	599	14	14	100.0	5,746	410
<i>Flebotomus elongatus</i>	14	..	..	..	..	15	..	..	..	..	14	..	..	..	..
<i>Corylophorus corylophorum</i>	14	..	..	..	..	15	3	20.0	214	71	14	5	35.7	403	81
<i>P. orthocollum</i>	14	1	7.1	73	72	15	..	..	..	..	14	..	..	..	..
<i>Fasciola gigantica</i>	14	11	78.6	131	12	15	15	100.0	177	12	14	14	100.0	143	10
<i>Metastodirus</i>	14	..	..	..	..	15	..	..	..	..	14	..	..	..	..
<i>Suaria tabiotopelilone</i>	14	14	100.0	94	7	15	14	93.3	90	6	14	14	100.0	74	5
<i>Thelazia nodosii</i>	14	..	..	..	..	15	..	..	..	..	14	..	..	..	..
<i>Brusistomum trigonocephalum</i>	14	..	..	..	..	15	..	..	..	..	14	..	..	..	..
<i>Oesophogostomum radiatum</i>	14	..	..	..	..	15	..	..	..	..	14	..	..	..	..

NOTE. In the calculation of average load per infection fractions of one-half or less have been omitted and those more than one-half counted as one.

TABLE VI—(contd.)
Statement showing incidence and intensity of infection in cattle

Name of parasites	July, 1940						August, 1940						September, 1940					
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection
<i>P. cerei</i>	14	11	78.6	1,270	115	6	1	16.7	301	301	14	14	100.0	2,680	194	14	14	100.0
<i>Gastrothylax trumentifer</i>	14	14	100.0	7,541	538	6	4	66.6	5,182	1,295	14	14	100.0	15,742	1,124	14	14	100.0
<i>Fischeriella elongatus</i>	14	..	..	..	..	6	..	..	..	..	14	..	..	..	..	14	..	..
<i>Corylophorus corylophorum</i>	14	6	42.8	308	51	6	2	33.3	409	240	14	4	28.6	353	89	14	4	28.6
<i>P. orthocentrum</i>	14	..	..	..	..	6	..	..	..	..	14	..	..	..	..	14	..	..
<i>Fasciola gigantica</i>	14	11	78.6	135	12	6	..	..	..	..	14	14	100.0	128	9	14	14	100.0
<i>Melittocitrus</i>	14	1	7.1	1	1	6	1	16.7	2	2	14	2	14.3	28	14	14	2	14.3
<i>Scaria labiatocapillata</i>	14	11	78.6	42	4	6	..	..	..	..	14	10	71.4	42	4	14	10	71.4
<i>Thelazia rhodesii</i>	14	..	..	..	..	6	..	..	..	..	14	..	..	..	..	14	..	..
<i>Braconium tripencapillum</i>	14	..	..	..	..	6	..	..	..	..	14	1	7.1	6	6	14	1	7.1
<i>Oesophagostomum radiatum</i>	14	..	..	..	..	6	..	..	..	..	14	1	7.1	11	11	14	1	7.1

NOTE. In the calculation of average load per infection fractions of one-half or less have been omitted and those more than one-half counted as one.

TABLE VI—(contd.)
Statement showing incidence and intensity of infection in cattle

Name of parasites	October, 1940						November, 1940						December, 1940					
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per	No. infected	No. examined	Per cent of infection	Total No. of parasites recovered	Average load per	No. infected	No. examined	Per cent of infection	Total No. of parasites recovered	Average load per	No. infected	No. examined	
<i>P. cervi</i>	12	10	83.3	1,470	147	15	14	93.3	2,948	211	16	16	100.0	3,085	191	16	16	
<i>Gastrophilus cruentifer</i>	12	12	100.0	8,051	671	15	15	100.0	5,812	387	16	16	100.0	9,224	576	16	16	
<i>Fasciolodiaris elongatus</i>	12	..	..	..	..	15	2	13.3	57	23	16	1	6.2	25	25	16	1
<i>Couphophorus coryphorum</i>	12	6	41.7	242	48	15	4	26.7	156	39	16	5	31.2	345	69	16	5	
<i>P. orthocotum</i>	12	..	..	..	..	15	..	..	..	..	16	..	..	..	..	16	..
<i>Fasciola gigantica</i>	12	7	58.3	46	7	15	14	93.3	184	13	16	12	75.0	319	26	16	12	
<i>Mesitocotrus</i>	12	1	8.3	12	12	15	3	20.0	14	5	16	4	25.0	81	8	16	4	
<i>Senaria labiniopapillosa</i>	12	8	66.7	8	8	15	10	66.7	55	6	16	15	93.8	92	6	16	15	
<i>Thelazia rhodesi</i>	12	..	..	..	..	15	..	..	..	..	16	..	..	..	..	16	..
<i>Bunostomum trigonocephalum</i>	12	..	..	..	..	15	1	6.7	11	11	16	..	..	..	..	16	..
<i>Oesophagostomum radiatum</i>	12	..	..	..	..	15	1	6.7	6	6	16	1	6.2	3	3	16	1

NOTE. In the calculation of average load per infection fractions of one-half or less have been omitted and those more than one-half counted as one.

TABLE VI—(contd.)
Statement showing incidence and intensity of infection in cattle

Name of parasite	January, 1941					February, 1941					March, 1941				
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection
<i>P. cervi</i>	12	12	100.0	2,397	191	13	13	100.0	2,433	187	12	12	100.0	2,720	227
<i>Gastrothylax crumenifer</i>	12	12	100.0	5,432	453	13	13	100.0	4,758	366	12	12	100.0	6,081	507
<i>Fischeloderia elongatus</i>	12	..	..	..	..	13	..	..	..	..	12	..	..	..	..
<i>Cotylophorm cotylophorum</i>	12	5	41.7	683	137	13	5	38.5	452	90	12	3	25.0	264	68
<i>P. orthocidium</i>	12	..	..	..	..	13	..	..	..	..	12	..	..	..	..
<i>Fasciola gigantica</i>	12	12	100.0	150	12	13	13	100.0	139	11	12	12	100.0	123	10
<i>Meloidiscus</i>	12	..	..	..	..	13	..	..	..	..	12	..	..	..	..
<i>Seraria laticapripitsea</i>	12	12	100.0	103	9	13	13	100.0	112	9	12	11	91.7	95	9
<i>Thelazia rhodesii</i>	12	..	..	..	..	13	..	..	..	..	12	..	..	..	..
<i>Eumastomus tripancephalus</i>	12	..	..	..	..	13	..	..	..	..	12	..	..	..	..
<i>Gesophorostomum rufitarsus</i>	12	..	..	..	..	13	..	..	..	..	12	..	..	..	..

NOTE. In the calculation of average load per infection, fractions of one-half or less have been omitted and those more than one-half counted as one.

TABLE VII

Statement showing incidence and intensity of infection in sheep

Name of parasites	April, 1939					May, 1939					June, 1939				
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal
<i>Paraphlastomum orthocollum</i>	22	4	18.2	94	22	24	2	8.3	59	30	25	8	32	330	41
<i>Paraphlastomum expleidum</i>	22	..	..	..	..	24	..	..	..	..	25	1	4	6	6
<i>Corylophorus corylophorum</i>	22	10	45.4	2,445	245	24	6	25	662	108	25	4	16	476	119
<i>Gastrothylax crumenifer</i>	22	15	68.2	3,353	324	24	19	79.2	3,305	174	25	24	96	4,161	178
<i>Pithecodictus clonatus</i>	22	..	..	..	..	24	..	..	..	..	25	..	..	..	..
<i>Fasciola gigantica</i>	22	1	4.5	3	3	24	1	4.2	9	0	25	4	16	38	9
<i>Eusynochus contortus</i>	22	7	31.7	28	4	24	7	29.2	136	19	25	5	20	22	4
<i>Bunostomum trigonocephalum</i>	22	13	59.1	101	8	24	12	50	53	5	25	10	76	282	15
<i>Scigeris pachysetis</i>	22	4	18.2	4	1	24	..	..	..	..	25	..	..	..	..
<i>Trichostrongylus colubriformis</i>	22	..	..	..	..	24	..	..	..	..	25	..	..	..	..
<i>Strongylidae papillorae</i>	22	1	4.5	20	20	24	..	..	..	..	25	..	..	..	..
<i>Gnathostomum columbianum</i>	22	15	68.2	132	12	24	19	82.5	364	19	25	23	92	643	28
<i>Trichostrongylus axei</i>	22	16	72.7	103	6	24	13	75	188	10	25	15	60	132	9
<i>Monilia expansa</i>	22	21	95.5	65	3	24	24	100	51	3	25	25	100	65	3
<i>Antelia centropunctata</i>	22	7	31.7	15	2	24	10	41.6	26	2	25	9	36	16	2
<i>Siluria globulicincta</i>	22	10	72.7	65	4	24	14	58.3	42	3	25	22	88	518	23

NOTE. In the calculation of average load per infection fractions of one-half or less have been omitted and those more than one-half counted as one.

TABLE VII—(contd.)
Statement showing incidence and intensity of infection in sheep

Name of parasites	July, 1959						August, 1959						September, 1959					
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	No. examined	No. infected	Per cent of infection
<i>Paramphistomum orthocotum</i>	23	13	56.5	1,272	98	24	4	16.6	408	102	23	..	..	..	..	23	..	..
<i>Paramphistomum expanseum</i>	23	..	..	..	..	24	1	4.2	37	37	23	..	..	..	..	23	..	..
<i>Cotyophorus cotylophorus</i>	23	4	17.4	558	139	24	9	37.5	902	100	23	10	43.5	3,380	339	23	..	..
<i>Gastrophilus cruentifer</i>	23	22	95.6	4,404	204	24	23	95.8	7,937	345	23	16	69.6	5,015	351	23	..	..
<i>Fistuloderus longatus</i>	23	..	..	..	..	24	1	4.2	3	3	23	1	4.3	2	2	23	..	..
<i>Fasciola gigantica</i>	23	1	4.3	1	1	24	..	..	..	..	23	..	..	..	..	23	..	..
<i>Hemonchus contortus</i>	23	3	13	83	28	24	12	50	388	32	23	23	95.6	1,190	54	23	..	..
<i>Punctotum trigonoccephalum</i>	23	19	82.6	299	16	24	21	87.5	146	7	23	23	100	144	6	23	..	..
<i>Gasteria pacyocella</i>	23	..	..	..	..	24	..	..	..	..	23	..	..	..	..	23	..	..
<i>Trichostrongylus colubriformis</i>	23	..	..	..	..	24	..	..	..	..	23	..	..	..	..	23	..	..
<i>Strongylidae papillosus</i>	23	..	..	..	..	24	..	..	..	..	23	..	..	..	..	23	..	..
<i>Oesophagostomum columbianum</i>	23	22	95.6	506	23	24	22	91.7	325	15	23	23	100	609	26	23	..	..
<i>Trichocephalus onis</i>	23	17	74	105	11	24	19	83.5	410	22	23	20	87	390	19	23	..	..
<i>Moniezia expansa</i>	23	23	100	41	2	24	24	100	60	2	23	23	100	95	4	23	..	..
<i>Avitaktia eurypanacea</i>	23	15	65.2	23	1	24	13	62.5	28	2	23	14	60.9	51	4	23	..	..
<i>Siliasta globipunctata</i>	23	23	100	686	29	24	22	91.7	825	13	23	23	100	574	25	23	..	..

NOTE. In the calculation of average load per infection. Fractions of one-half or less have been omitted and those more than one-half counted as one.

TABLE VII—(contd.)
Statement showing incidence and intensity of infection in sheep

Name of parasite	October, 1939						November, 1939						December, 1939					
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the	Average animal load per	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the	Average animal load per	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the	Average animal load per	No. examined	No. infected	Per cent of infection
<i>Paraphitium orthocotum</i>	24	1	4.2	176	170	23	1	4.3	19	19	22	..	..	..	..	..	..	..
<i>Paraphitium explanatum</i>	24	1	4.2	16	16	23	..	..	..	..	22	1	4.5	5	5	22	1	4.5
<i>Cotylephora ocelliphora</i>	24	9	27.5	12,875	319	23	13	56.5	4,442	329	22	19	86.4	4,920	286	22	19	86.4
<i>Gastrothylax crumenifer</i>	24	20	83.3	6,080	334	23	17	74	2,573	151	22	13	59.1	1,051	81	22	13	59.1
<i>Fischelertius longitus</i>	24	..	..	..	..	23	..	..	..	..	22	..	..	..	..	..	..	..
<i>Fasciola gigantica</i>	24	..	..	..	..	23	..	..	..	..	22	..	..	..	..	..	..	..
<i>Haemonchus contortus</i>	24	14	58.3	396	28	23	14	60.9	160	12	22	16	72.7	325	20	22	16	72.7
<i>Eusotomium triponecephalum</i>	24	18	75	153	8	23	20	87	217	11	22	20	90.9	214	11	22	20	90.9
<i>Gasteria pachycauda</i>	24	1	4.2	2	2	23	1	4.3	2	2	22	3	13.6	12	4	22	3	13.6
<i>Trichostrongylus colubriformis</i>	24	..	..	..	..	23	..	..	..	..	22	..	..	..	..	..	..	..
<i>Strongyloides papillosus</i>	24	..	..	..	..	23	..	..	..	..	22	1	4.5	6	6	22	1	4.5
<i>Oesophagostomum columbianum</i>	24	22	91.7	468	21	23	22	91.7	366	16	22	21	95.4	346	16	22	21	95.4
<i>Trichocephalus ovis</i>	24	22	91.7	229	10	23	21	91.3	178	8	22	21	95.4	231	11	22	21	95.4
<i>Moniezia expansa</i>	24	23	95.8	112	5	23	23	100	131	6	22	22	100	71	3	22	22	100
<i>Achilina centripunctata</i>	24	13	62.5	47	5	23	13	56.5	33	3	22	19	86.3	42	2	22	19	86.3
<i>Silezia globipunctata</i>	24	23	95.8	482	21	23	23	100	595	23	22	22	100	592	27	22	22	100

NOTE. In the calculation of average load per infectious fraction of one-half or less have been omitted and those more than one-half counted as one.

TABLE VII—(contd.)
Statement showing incidence and intensity of infection in sheep

Name of parasites	January, 1940						February, 1940						March, 1940					
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the	Average load per animal		No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the	Average load per animal		No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the	Average load per animal	
<i>Paraphitomon orthocentrum</i>	25	1	4	6	6		22	2	9.1	147	73	21	21	..	..	1,385	99	..
<i>Paraphitomon exilicatum</i>	25	1	4	77	77		22	2	9.1	2,500	267	21	21	..	..	2,695	225	..
<i>Cylophoron cylophorum</i>	25	16	64	3,714	232		22	15	68.2	1,793	163	21	21	14	66.6	..	..	..
<i>Gastrothylax cruentifer</i>	25	14	56	1,788	133		22	11	50	..	..	21	21	12	57.1	..	..	..
<i>Frichodierius longius</i>	25	..	..	..	..		22	..	..	..	..	21	21	..	..	..	..	..
<i>Fasciola gigantica</i>	25	..	..	..	..		22	2	9.1	2	1	21	21	..	..	..	..	..
<i>Hemonchus contortus</i>	25	6	24	40	7		22	12	55.5	141	12	21	21	13	61.9	115	9	..
<i>Eristomon triconoccephalum</i>	25	23	92	491	21		22	21	95.4	426	20	21	21	19	90.5	189	10	..
<i>Galerita pachyscelis</i>	25	5	20	9	2		22	5	22.7	9	9	21	21	6	28.6	13	2	..
<i>Trichostrongylus colubriformis</i>	25	..	..	..	..		22	..	..	..	..	21	21	..	..	..	..	..
<i>Strongyloides papillosus</i>	25	1	4	12	12		22	1	4.5	11	11	21	21	..	..	..	..	..
<i>Oesophaphostomum columbianum</i>	25	22	88	180	8		22	21	95.4	243	12	21	21	17	81	184	11	..
<i>Trichocephalus ovis</i>	25	25	100	1,234	49		22	23	100	843	38	21	21	20	95.2	659	38	..
<i>Moniezia expansa</i>	25	25	100	87	3		22	22	100	77	3	21	21	21	100	39	2	..
<i>Actelasma curvicauda</i>	25	21	84	42	2		22	14	63.7	35	2	21	21	19	90.5	65	3	..
<i>Stilesia gabriellana</i>	25	25	100	817	33		22	22	100	651	29	21	21	21	100	333	16	..

NOTE. In the calculation of average load per infection fractions of one-half or less have been omitted while those more than one-half counted as one.

TABLE VII--(contd.)
Statement showing incidence and intensity of infection in sheep

Name of parasites	April, 1940						May, 1940						June, 1940					
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection
<i>Oedophorus edrophorus</i>	25	16	64	3,680	183	26	17	65.4	1,714	101	24	16	66.6	1,853	16	66.6	1,853	122
<i>P. orthocellum</i>	25	1	4	71	71	26	3	7.7	273	136	24	..	..	..	..	..	..	..
<i>Gasterophilus crumenifer</i>	25	10	40	1,355	135	26	18	69.2	3,458	192	24	20	83.3	3,480	24	83.3	3,480	174
<i>Fasciola gigantica</i>	25	..	..	..	..	26	..	..	..	..	24	..	..	..	..	..	..	..
<i>P. explanatum</i>	25	1	4	116	116	26	..	..	..	..	24	..	..	..	..	..	..	..
<i>Bunostomum trigonocephalum</i>	25	23	92	482	19	26	24	92.3	525	9	24	16	66.6	69	..	..	..	4
<i>Gedria yacquelis</i>	25	3	12	3	3	26	3	11.2	9	2	24	..	..	..	..	..	..	..
<i>Haemonchus contortus</i>	25	9	36	71	8	26	12	46.1	95	8	24	11	45.8	83	..	..	..	3
<i>Oesophagostomum columbianum</i>	25	21	84	140	7	26	8	30.8	62	9	24	13	54.2	68	..	..	..	4
<i>Trichostrongylus axei</i>	25	24	96	586	24	26	25	96.1	457	18	24	24	100.0	423	..	..	..	17
<i>Trichostrongylus colubriformis</i>	25	..	..	..	..	26	..	..	..	..	24	..	..	..	..	..	..	..
<i>Strongylus papillosus</i>	25	1	4	4	4	26	..	..	..	..	24	..	..	..	..	..	..	..
<i>Monileia expansa</i>	25	25	100	54	2	26	23	100.0	57	2	24	24	100.0	47	..	..	..	2
<i>Asiaticus contriguenda</i>	25	18	72	40	2	26	14	53.8	26	1	24	12	50.0	17	..	..	..	1
<i>Stella globulicollis</i>	25	23	92	292	11	26	25	100.0	455	19	24	24	100.0	347	..	..	..	14

N.B.—In the calculation of average load per infection fractions of one-half or less have been omitted while those more than one-half counted as one.

TABLE VII—(contd.)
Statement showing incidence and intensity of infection in sheep

Name of parasites	July, 1940						August, 1940						September, 1940					
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per		No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per		No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per	
<i>Coelophoron coliformorum</i>	27	14	51.5	1,846	132		25	23	92	5,352	228		24	19	79.2	4,327	223	
<i>P. orthocellum</i>	27	1	3.7	74	74		25	..	..	..	..		24	..	..	..	..
<i>Gnatholites crumenifer</i>	27	26	96.3	6,769	261		25	25	100	11,800	476		24	20	83.3	7,963	393	
<i>Fasciola gigantica</i>	27	..	..	..	..		25	..	..	..	..		24	..	..	..	..
<i>P. explanatum</i>	27	..	..	..	..		25	..	..	..	..		24	..	..	..	..
<i>Bunostomum trigonocephalum</i>	27	24	88.9	205	8		25	23	88	393	13		24	20	83.3	170	9	
<i>Gaigeria pachyscelis</i>	27	..	..	..	..		25	..	..	..	..		24	1	4.2	1	1	
<i>Hemonchus contortus</i>	27	18	66.6	117	6		25	18	72	373	21		24	23	91.7	922	37	
<i>Orophastomum edmuntianum</i>	27	19	70.4	174	9		25	16	64	169	10		24	22	91.7	178	8	
<i>Trichocephalus oris</i>	27	27	100.0	908	34		25	25	100	871	35		24	24	100.0	614	26	
<i>Trichostrongylus colubriformis</i>	27	..	..	..	..		25	..	..	..	..		24	..	..	..	..
<i>Strongyloides papillosus</i>	27	..	..	..	..		25	..	..	..	..		24	..	..	..	..
<i>Moniezia expansa</i>	27	27	100.0	66	2		25	25	100	73	3		24	24	100.0	102	4	
<i>Aelictus centrifugatus</i>	27	17	63.0	35	2		25	12	48	30	2		24	10	41.7	13	2	
<i>Stilesia gabriellana</i>	27	27	100.0	433	16		25	25	100	687	27		24	24	100.0	612	26	

NOTE. In the calculation of average load per infection fractions of one-half or less have been omitted while those more than one-half counted as one.

TABLE VII—(contd.)

Statement showing incidence and intensity of infection in sheep

Name of parasites	October, 1940					November, 1940					December, 1940				
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection
<i>Gaighophoren colyophorum</i>	19	11	58.0	2,120	193	23	14	60.8	2,146	153	23	8	34.8	1,124	140
<i>P. orthocotum</i>	19	..	..	..	..	23	..	..	..	..	23	..	..	..	..
<i>Gaighophoren crumifer</i>	19	15	79.0	3,930	262	23	15	65.2	4,296	286	23	9	39.1	1,389	171
<i>Fasciola gigantica</i>	19	..	..	..	..	23	..	..	..	..	23	..	..	..	..
<i>P. explanatum</i>	19	..	..	..	..	23	..	..	..	..	23	..	..	..	..
<i>Bunostomum trigonocephalum</i>	19	14	73.7	130	9	23	15	65.2	117	8	23	14	60.8	45	3
<i>Gaighoren gaudyensis</i>	19	..	..	..	..	23	1	4.3	1	1	23	1	4.3	4	4
<i>Haemonchus contortus</i>	19	16	84.2	183	11	23	8	34.8	147	18	23	14	60.8	188	9
<i>Oesophagostomum edentatum</i>	19	18	94.7	142	8	23	14	60.8	134	9	23	11	47.8	45	4
<i>Trichocephalus ovis</i>	19	18	94.7	250	15	23	22	95.6	199	9	23	21	91.3	127	6
<i>Trichostrongylus colubriformis</i>	19	..	..	..	..	23	..	..	..	..	23	..	..	..	..
<i>Strongyloides papillosus</i>	19	..	..	..	..	23	3	13.0	63	21	23	..	..	..	..
<i>Monilia capensis</i>	19	19	100.0	131	8	23	23	100.0	195	5	23	22	95.6	73	4
<i>Astilina canaliculata</i>	19	7	37.0	37	5	23	15	65.2	55	4	23	14	60.8	28	2
<i>Sitona globipunctata</i>	19	19	100.0	464	24	23	21	91.3	270	13	23	18	78.2	127	7

NOTE. In the calculation of average load per infection fractions of one-half or less have been omitted while those more than one-half counted as one.

TABLE VII—(concl.)
Statement showing incidence and intensity of infection in sheep

Name of parasites	January, 1941					February, 1941					March, 1941				
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection
<i>Coryliophoron coryliophorum</i>	23	12	52.2	978	81	16	4	25.0	304	76	22	6	27.3	929	155
<i>P. orthocentrus</i>	23	6	26.1	327	54	16	3	18.7	927	309	22	5	22.7	1,223	243
<i>Gastrophilus crumifer</i>	23	..	..	..	..	16	..	..	..	..	22	..	..	..	..
<i>Fasciola gigantica</i>	23	..	..	..	..	16	..	..	..	..	22	..	..	..	..
<i>P. caplandum</i>	23	..	..	..	..	16	..	..	..	..	22	..	..	..	..
<i>Dicrocoelium trigonocephalum</i>	23	20	87.0	389	19	16	13	81.2	316	94	22	10	80.9	174	9
<i>Gyrodactylus pascuensis</i>	23	..	..	..	..	16	..	..	..	..	22	3	13.0	8	3
<i>Harmothys contortus</i>	23	14	60.8	326	23	16	8	50.0	205	26	22	9	40.9	40	4
<i>Oxyphodonomus columbianus</i>	23	10	43.5	115	11	16	5	31.2	74	15	22	15	68.2	191	13
<i>Trichocephalus ovis</i>	23	21	91.3	414	20	16	16	100.0	184	11	22	16	72.7	109	12
<i>Trichostrongylus axei</i>	23	..	..	..	..	16	..	..	..	..	22	..	..	..	..
<i>Strongylus edentatus</i>	23	1	4.3	13	13	16	..	..	..	..	22	1	4.5	30	30
<i>Monilia expansa</i>	23	21	91.3	31	1	16	15	93.7	30	2	22	22	100.0	43	2
<i>Antellina centropuncta</i>	23	15	65.2	50	3	16	8	50.0	40	5	22	14	63.6	29	2
<i>Sitona globipuncta</i>	23	23	100.0	394	17	16	16	100.0	210	14	22	21	95.4	216	10

NOTE. In the calculation of average load per infection fractions of one-half or less have been omitted while those more than one-half counted as one.

TABLE VIII

Statement showing incidence and intensity of infection in goats

Name of parasites	April, 1939					May, 1939					June, 1939				
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal
<i>Paramphistomum orthocostum</i>	22	8	36.3	530	67	24	2	8.3	142	71	25	5	20	244	49
<i>Paramphistomum caplandum</i>	22	..	..	..	..	24	1	4.2	7	7	25	..	..	..	..
<i>Cotloglyphum colloglyphum</i>	22	13	59.1	248.2	182	24	8	33.3	793	99	25	5	20	506	100
<i>Gastrophilus cruentifer</i>	22	12	54.5	2140	176	24	20	83.3	2,851	117	25	22	88	3,860	153
<i>Trichostrongylus axei</i>	22	..	..	..	..	24	..	..	..	..	25	..	..	..	..
<i>Trichostrongylus axei</i>	22	8	36.3	35	12	24	..	..	..	..	25	..	..	..	..
<i>Hemonchus contortus</i>	22	4	18.2	55	16	24	0	0	45	8	25	7	28	98	5
<i>Euzootomus trizonocercatum</i>	22	19	86.3	222	13	24	10	41.6	104	7	25	19	76	185	10
<i>Gasterophilus plicatus</i>	22	4	18.2	8	2	24	3	12.5	4	1	25	..	..	..	..
<i>Trichostrongylus colubriformis</i>	22	..	..	..	..	24	1	4.2	10	10	25	1	4	1	1
<i>Strongylus pupillatus</i>	22	..	..	..	..	24	..	..	..	..	25	..	..	..	..
<i>Gastrophilus edentatus</i>	22	20	90.9	241	12	24	20	83.3	209	15	25	25	100	558	23
<i>Trichostrongylus axei</i>	22	10	45.5	126	8	24	15	62.5	151	10	25	15	60	152	10
<i>Monilia expansa</i>	22	4	18.2	4	1	24	4	16.7	5	1	25	20	80	34	2
<i>Artibeus cervicivorus</i>	22	18	81.8	64	3	24	18	75	25	4	25	11	44	25	2
<i>Altitia globipunctata</i>	22	21	95.4	428	27	24	23	95.8	475	26	25	24	96	558	15

NOTE. In the calculation of average load per infection fractions of one-half or less have been omitted while those more than one-half counted as one.

TABLE VIII—(contd.)
Statement showing incidence and intensity of infection in goats

Name of parasites	July, 1959						August, 1959						September, 1959			
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal		No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal		No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals
<i>Paramphistomum colonicum</i>	23	7	30	636	..	91	24	6	25	294	49	..	23	..	..	..
<i>Paramphistomum espartanum</i>	23	..	..	..	..	363	24	1	4.2	16	16	..	23	..	..	..
<i>Cedrophoron eddyphorum</i>	23	8	35	2,720	..	305	24	11	45.8	1,105	100	..	23	11	48	2,285
<i>Gastrodylus crassusifer</i>	23	19	82.7	3,417	..	179	24	19	80	4,087	247	..	23	7	30.4	1,060
<i>Flaschodius elongatus</i>	23	..	..	..	..	..	24	1	4.2	3	3	..	23	..	..	..
<i>Pecidia nigritica</i>	23	..	..	..	..	..	24	..	..	..	..	..	23	1	4.3	3
<i>Hemonchus contortus</i>	23	5	21.7	70	..	14	24	12	50	329	27	..	23	21	91.3	1,147
<i>Bunostomum trigonocephalum</i>	23	20	87	216	..	11	24	19	79.1	121	6	..	23	17	74	62
<i>Gasteria pachyseta</i>	23	..	..	..	..	..	24	..	..	..	..	..	23	1	4.4	1
<i>Trichostrongylus colubriformis</i>	23	..	..	..	..	..	24	..	..	..	..	..	23	..	..	..
<i>Strongylides papillosus</i>	23	..	..	..	..	..	24	..	..	..	..	..	23	..	..	..
<i>Oesophagostomum edentatum</i>	23	21	91.3	400	..	23	24	20	83.3	225	11	..	23	17	74	493
<i>Trichostrongylus axei</i>	23	13	56.5	109	..	9	24	20	83.3	232	12	..	23	19	82.6	230
<i>Moniezia expansa</i>	23	22	95.6	48	..	2	24	24	100	48	9	..	23	23	100	68
<i>Artedius entripunctata</i>	23	16	69.6	51	..	3	24	9	37.5	11	1	..	23	13	56.1	38
<i>Sitelen globipunctata</i>	23	23	100	458	..	29	24	22	91.7	394	14	..	23	23	100	452

NOTE. In the calculation of average load per infection fractions of one-half or less have been omitted while those more than one-half counted as one.

TABLE VIII—(contd.)
Statement showing incidence and intensity of infection in goats

Name of Parasites	October, 1939					November, 1939					December, 1939				
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal
<i>Paramphistomum orthocaulum</i>	23	..	..	..	..	23	..	..	..	..	23	..	..	..	..
<i>Paramphistomum expulsum</i>	23	..	..	..	..	23	..	..	..	..	23	..	..	..	..
<i>Gastrophilus edaphorum</i>	23	11	48	2,337	214	23	16	70	3,792	237	22	17	74	9,371	210
<i>Gastrophilus cruentifer</i>	23	17	74	3,382	199	23	7	30.4	1,105	153	22	8	34.4	311	39
<i>Fistularia elongatus</i>	23	..	..	..	..	23	..	..	..	..	22	..	..	..	..
<i>Fistula signata</i>	23	..	..	..	..	23	..	..	..	..	22	..	..	..	..
<i>Hemonchus contortus</i>	23	12	52.2	277	23	23	12	52.2	169	13	22	14	63.6	267	19
<i>Bunostomum triconocephalum</i>	23	15	65.2	112	8	23	19	82.6	163	8	22	18	81.8	118	7
<i>Gnigeria pachyscelis</i>	23	..	..	..	..	23	1	4.3	1	1	22	1	4.5	2	..
<i>Trichostrongylus colubriformis</i>	23	..	..	..	..	23	..	..	..	..	22	..	..	..	..
<i>Strongyloides papillosus</i>	23	..	..	..	..	23	..	..	..	..	22	..	..	..	..
<i>Gesophagostomum edaphanum</i>	23	22	95.6	285	13	24	20	87	366	15	22	21	95.4	240	11
<i>Trichocephalus axei</i>	23	18	81.8	142	6	23	19	82.6	122	6	22	20	91	171	9
<i>Monileia caprina</i>	23	22	95.6	110	5	23	23	100	139	6	22	22	100	53	2
<i>Aicollina centrigeneta</i>	23	11	48	36	3	23	9	39.1	16	2	22	13	59.1	24	14
<i>Sitisia globipendula</i>	23	21	91.3	201	14	23	28	100	445	19	22	22	100	340	15

NOTE. In the calculation of average load per infection fractions of one-half or less have been omitted while those more than one-half counted as one.

TABLE VIII.—(contd.)
Statement showing incidence and intensity of infection in goats

Name of parasites	January, 1940						February, 1940						March, 1940					
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal		No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal		No. examined	No. infected	Per cent of infection	Total No. of parasites recovered from the infected animals	Average load per animal	
<i>Paramphistomum colicoecium</i>	25	..	..	..	..	..	22	..	..	..	..	..	21	..	..	..	..	..
<i>Paramphistomum ceptanepum</i>	25	..	..	..	..	..	22	..	..	..	..	..	21	..	..	..	..	..
<i>Oxyphoron oxyphorum</i>	25	13	52	1,425	109	..	22	13	59.1	3,469	102	..	21	13	62	1,409	115	..
<i>Gastrophilus cruentifer</i>	25	7	28.0	762	107	..	22	7	31.8	843	121	..	21	10	47.6	2,069	207	..
<i>Fistiodactylus elongatus</i>	25	..	..	..	..	..	22	..	..	..	..	..	21	..	..	..	..	..
<i>Fistiodactylus gigantis</i>	25	..	..	..	..	..	22	..	..	..	..	..	21	..	..	..	..	..
<i>Hemonchus contortus</i>	25	5	20	18	4	..	22	11	50	75	7	..	21	12	57.1	75	6	..
<i>Buxostomum trigonocephalum</i>	25	25	100	265	11	..	22	21	95.4	267	13	..	21	19	90.5	122	6	..
<i>Galoria pacificus</i>	25	5	20	7	1	..	22	3	13.6	3	1	..	21	6	28.6	10	2	..
<i>Trichostrongylus colubriformis</i>	25	..	..	..	..	..	22	..	..	..	..	..	21	..	..	..	..	..
<i>Strongyloides papillosus</i>	25	..	..	..	..	..	22	..	..	..	..	..	21	..	..	..	..	..
<i>Oesophagostomum columbianum</i>	25	17	68	102	6	..	22	19	86.4	141	7	..	21	14	66.7	153	11	..
<i>Trichocephalus axei</i>	25	25	100	570	23	..	22	23	100	477	23	..	21	21	100	450	21	..
<i>Moniezia expansa</i>	25	25	100	59	2	..	22	22	100	49	2	..	21	20	95.2	24	2	..
<i>Antellina entrypimentata</i>	25	14	56	23	2	..	22	13	59.1	26	2	..	21	19	90.5	45	2	..
<i>Sitisia globipunctata</i>	25	25	100	398	16	..	22	22	100	492	22	..	21	20	95.2	323	16	..

NOTE. In the calculations of average load per infection fractions of one-half or less have been omitted and those more than one-half counted as one.

TABLE VIII--(contd.)
Statement showing incidence and intensity of infection in goats

Name of parasites	April, 1940						May, 1940						June, 1940					
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection		No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection		No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	
<i>Controphaen cotylophorum</i>	25	16	64.0	1,941	121		25	10	40	1,711	171		24	13	54.1	1,548	119	
<i>Paramphistomum orthocentum</i>	25	1	4.0	20	20		25	1	4	70	70		24	..	..	..	..
<i>Gastrophilus crumifer</i>	25	7	28.0	1,069	153		25	15	60	2,828	188		24	16	66.6	2,885	180	
<i>Bunostomum trigonocephalum</i>	25	20	80.0	144	7		25	21	84	150	7		24	12	50.0	45	4	
<i>Haemonchus contortus</i>	25	11	44.0	98	9		25	11	44	68	6		24	10	41.6	57	6	
<i>Gyneris pachyella</i>	25	5	20.0	8	2		25	3	12	4	1		24	..	..	..	..
<i>Oesophagostomum edentatum</i>	25	20	80.0	117	6		25	8	32	71	9		24	14	58.3	54	4	
<i>Trichocephalus ovis</i>	25	23	92.0	490	21		25	25	100	361	14		24	24	100.0	430	18	
<i>Strongylus pyralis</i>	25	..	..	..	..		25	..	..	..	..		24	..	..	..	..
<i>Monilia expansa</i>	25	23	92.0	32	1		25	25	100	43	2		24	24	100.0	39	2	
<i>Artellia centipuncta</i>	25	23	92.0	65	3		25	13	52	21	2		24	9	37.5	15	2	
<i>Sitisia globipunctata</i>	25	23	92.0	245	11		25	25	100	383	13		24	24	100.0	272	11	

NOTE. In the calculations of average load per infection fractions of one-half or less have been omitted and those more than one half counted as one.

TABLE VIII -- (contd.)
Statement showing incidence and intensity of infection in goats

Name of parasite	July, 1940						August, 1940						September, 1940					
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection
<i>Codiplopora coloplorum</i>	27	9	33.3	1,210	145	25	22	88	5,220	236	24	18	75.0	3,188	177	24	18	75.0
<i>Paramphistomum orthocotyle</i>	27	..	..	..	..	25	..	..	..	..	24	..	..	..	..	24	..	..
<i>Gastrophilus crumifer</i>	27	23	85.2	4,062	170	25	20	80	3,550	178	24	17	71.0	4,119	60	24	17	71.0
<i>Eusotomus trigonocephalum</i>	27	19	70.4	113	6	25	22	88	240	11	24	21	87.5	79	4	24	21	87.5
<i>Butechus contortus</i>	27	17	63.0	127	7	25	19	76	343	18	24	23	95.0	830	36	24	23	95.0
<i>Gastrophilus yachnealis</i>	27	..	..	..	..	25	..	..	..	..	24	..	..	..	..	24	..	..
<i>Oesophagostomum columbianum</i>	27	20	74.0	210	11	25	18	72	167	9	24	19	79.1	187	7	24	19	79.1
<i>Trichocephalus axei</i>	27	27	100.0	617	23	25	25	100	837	33	24	24	100.0	557	23	24	24	100.0
<i>Strongylides papillosus</i>	27	..	..	..	..	25	..	..	..	..	24	..	..	..	..	24	..	..
<i>Moniezia expansa</i>	27	26	96.3	41	2	25	25	100	50	2	24	24	100.0	74	3	24	24	100.0
<i>Astilata entricapitata</i>	27	14	51.8	24	2	25	11	44	83	3	24	8	33.3	14	2	24	8	33.3
<i>Silisia globipunctata</i>	27	27	100.0	439	16	25	25	100	714	28	24	24	100.0	627	26	24	24	100.0

NOTE. In the calculations of average load per infection fractions of one-half or less have been omitted and those more than one-half counted as one.

TABLE VIII—(contd.)
Statement showing incidence and intensity of infection in goats

Name of parasites	October, 1940					November, 1940					December, 1940				
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection
<i>Coxyliodon colyphorum</i>	10	10	100.0	2,854	285.4	23	10	69.6	4,301	200	23	7	30.4	201	37
<i>Paramphistomum orthocellum</i>	10	1	10.0	135	13.5	23	..	..	..	..	23	..	..	..	..
<i>Gastrophilus cruentifer</i>	19	15	78.9	4,130	275	23	9	39.1	765	88	23	7	30.4	305	56
<i>Eusotomium triloncephalum</i>	19	13	68.4	90	7	23	0	0.0	70	8	23	13	56.5	40	3
<i>Hemonchus contortus</i>	10	14	140.0	221	16	23	5	21.7	129	26	23	11	47.8	143	13
<i>Gastrophilus pachysyllis</i>	19	..	..	..	..	23	..	..	..	..	23	1	4.3	1	1
<i>Oesophagostomum columbianum</i>	19	16	84.2	182	11	23	14	60.9	123	9	23	9	39.1	66	7
<i>Trichocephalus axei</i>	19	19	100.0	362	16	23	16	69.6	180	12	23	21	91.3	100	8
<i>Strongylus papillosus</i>	19	..	..	..	..	23	1	4.3	2	2	23	1	4.3	22	22
<i>Monilia expansa</i>	19	17	89.5	89	5	23	23	100.0	96	4	23	18	78.3	57	3
<i>Aetidia contripunctata</i>	19	7	37.0	23	4	23	9	39.1	26	3	23	11	47.8	60	6
<i>Siluria globipunctata</i>	19	19	100.0	436	23	23	20	87.0	316	16	23	23	100.0	160	7

NOTE. In the calculations of average load per infection fractions of one-half or less have been omitted and those more than one-half counted as one.

TABLE VIII—(concl.)
Statement showing incidence and intensity of infection in goats

Name of parasite	January, 1941						February, 1941						March, 1941				
	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	No. infected	Per cent of infection	Total No. of parasites recovered	Average load per infection	No. examined	Average load per infection
<i>Corylophoron collyporum</i>	23	10	43.5	903	96	16	3	18.8	109	36	22	4	18.1	294	73	22	73
<i>Paramphistomum orthostomum</i>	23	..	..	..	..	16	..	..	..	..	22	..	..	..	..	..	..
<i>Gastrophyta erinacei</i>	23	4	17.4	100	47	16	3	18.8	427	142	22	5	22.7	2,175	435	22	435
<i>Bunostomum trigonocephalum</i>	23	11	48.0	92	8	16	13	81.2	172	13	22	14	63.6	119	8	22	8
<i>Hemonchus contortus</i>	23	19	82.6	137	10	16	8	50.0	130	16	22	11	50.0	50	5	22	5
<i>Galeria gadycella</i>	23	..	..	..	..	16	..	..	..	..	22	..	..	..	..	..	..
<i>Oesophagostomum colubiforme</i>	23	12	52.1	64	5	16	7	43.7	46	6	22	15	68.1	122	8	22	8
<i>Trichocephalus axei</i>	23	20	87.0	277	14	16	15	93.7	147	10	22	18	81.7	237	18	22	18
<i>Strongyloides papillosus</i>	23	1	4.3	126	126	16	1	6.2	70	79	22	1	4.5	16	16	22	16
<i>Moniezia expansa</i>	23	20	87.0	28	1	16	14	87.5	25	25	22	22	100.0	29	1	22	1
<i>Acetabularia caripuncata</i>	23	7	30.4	18	8	16	11	68.8	35	3	22	13	59.1	31	2	22	2
<i>Stilesia debignyi</i>	23	23	100.0	282	12	16	15	93.7	115	10	22	20	90.9	270	13	22	13

NOTE. In the calculations of average load per infection fractions of one-half or less have been omitted and those more than one-half counted as one.

TABLE IX A

Incidence and intensity of infection with *Olveria indica*, *Olveria bosi* and *Paramphistomum gotoi* *in buffalo of Lucknow from June, 1950 to May, 1951*

Month	<i>Olveria indica</i>				
	Number examined	Number infected	Percentage of infection	Total No. of parasites recovered	Average load per animal
June 1950	10	9	90	550	61
July 1950	14	9	64.2	2,357	261
August 1950	22	10	45.4	6,488	648
September 1950	14	9	50	6,850	761
October 1950	16	11	68.7	3,380	307
November 1950	20	8	40	1,702	212
December 1950	18	10	55.5	2,510	251
January 1951	20	14	70	7,866	561
February 1951	18	14	77.7	5,176	509
March 1951	20	8	40	714	89
April 1951	21	10	47.6	13,276	1,327
May 1951	17	6	35.2	1,106	184

TABLE IX A—(contd.)

*Incidence and intensity of infection with *Olveria indica*, *Olveria bosi* and *Paramphistomum gotoi* in buffalo of Lucknow from June, 1950 to May, 1951*

Month	<i>Olveria bosi</i>				
	Number examined	Number infected	Percentage of infection	Total No. of parasites recovered	Average load per animal
June 1950	10	1	10	38	38
July 1950	14	—	—	—	—
August 1950	22	3	13.6	49	10
September 1950	18	2	11.1	300	150
October 1950	16	1	6.2	288	288
November 1950	20	4	20	1,080	272
December 1950	18	2	11	17	8
January 1951	20	—	—	—	—
February 1951	18	3	16.6	6,950	2,118
March 1951	20	1	5	325	325
April 1951	21	3	14.2	277	92
May 1951	17	3	17.6	1,190	396

TABLE IX A—(contd.)

Incidence and intensity of infection with *Olveria indica*, *Olveria bovis* and *Paramphistomum gotoi* *in buffalo of Lucknow from June, 1950 to May, 1951*

Month	<i>Paramphistomum gotoi</i>				
	Number examined	Number infected	Percentage of infection	Total No. of parasites recovered	Average load per animal
June 1950	10	1	10	55	55
July 1950	14	—	—	—	—
August 1950	22	4	18.1	2,274	563
September 1950	18	2	11.1	102	51
October 1950	16	1	6.2	80	80
November 1950	20	—	—	—	—
December 1950	13	—	—	—	—
January 1951	20	3	15	25	8
February 1951	13	2	11.1	946	473
March 1951	20	2	10	406	203
April 1951	21	2	9.5	91	45
May 1951	17	1	5.8	22	22

TABLE IX B

Incidence and intensity of infection with *Olveria indica*, *Olveria bovi* and *Paramphistomum govti* *in buffalo of Lucknow from June, 1951 to May, 1952*

Month	<i>Olveria indica</i>				
	Number examined	Number infected	Percentage of infection	Total No. of parasites recovered	Average load per animal
June 1951	16	7	43.7	852	121
July 1951	19	8	42.1	1,455	181
August 1951	17	9	52.9	275	80
September 1951	19	8	42.1	5,825	728
October 1951	14	6	42.8	2,818	409
November 1951	17	11	64.7	5,171	470
December 1951	16	7	43.7	445	63
January 1952	17	8	47	7,821	977
February 1952	19	10	52.6	8,403	840
March 1952	18	9	50	7,515	835
April 1952	18	10	55.6	1,127	112
May 1952	21	13	61.9	6,342	487

TABLE IX B—(contd.)

*Incidence and intensity of infection with *Olveria indica*, *Olveria bosi* and *Paramphistomum gatoi* in buffalo of Lucknow from June, 1951 to May, 1952*

Month	Number Examined	<i>Olveria bosi</i>			
		Number Infected	Percentage of Infection	Total No. of parasites recovered	Average load per animal
June 1951	10	—	—	—	—
July 1951	19	1	5.2	144	144
August 1951	17	2	11.7	70	35
September 1951	19	1	5.2	10	10
October 1951	14	2	14.2	435	217
November 1951	17	1	5.8	18	18
December 1951	16	2	12.5	21	10
January 1952	17	1	5.8	60	60
February 1952	19	1	5.2	15	15
March 1952	18	3	16.6	1,091	363
April 1952	18	3	16.6	1,108	369
May 1952	21	3	14.2	190	63

TABLE IX B—(contd.)

Incidence and intensity of infection with *Olveria indica*, *Olveria bovi* and *Paramphistomum gotoi* *in buffalo of Lucknow from June, 1951 to May, 1952*

Month	Number Examined	<i>Paramphistomum gotoi</i>			
		Number Infected	Percentage of Infection	Total No. of parasites recovered	Average load per animal
June 1951	16	1	6.2	8	8
July 1951	10	—	—	—	—
August 1951	17	1	5.8	18	18
September 1951	10	2	10.5	403	246
October 1951	14	1	7.1	30	30
November 1951	17	1	5.8	3,405	3,405
December 1951	16	—	—	—	—
January 1952	17	1	5.8	6	6
February 1952	10	2	10.5	2,582	1,291
March 1952]	18	3	16.6	2,449	833
April 1952]	18	3	16.6	290	96
May 1952	21	2	9.5	27	13

CONCLUSION

Foregoing data reveal some very important results. It would be observed that some parasites are very common and show heavy degree of infection while others are rare and occasional. Of these, amphistomes are abundantly found in all the four ruminants, buffaloes, cattle, sheep and goats. *Gastrothylax crumenifer* and *Cotylophoron cotylophorum* are very common and show maximum degree of infection and heavy load per animal, the highest degree of infection being during the rainy season. Other amphistomes when present are not so abundant and are generally seasonal.

Olveria indica [Thapar and Sinha 1945] is very common in cattle and buffaloes, while *Olveria hosi* [Tandon 1951] and *Paramphistomum gotoi* are very common in buffaloes, at any rate in Lucknow where the incidence and intensity of infection for these parasites have been studied. Fukui [1926] and Dawes [1936] have both reported the occurrence of *P. gotoi* as a rare parasite in the Far East and Malaya respectively. Our observations, however, at Lucknow indicate that it is fairly common in buffaloes, showing heaviest infection during the months of November to April when most of the specimens are immature. From May onwards mature specimens are encountered in this host.

It may be observed that certain other amphistomes have been reported for the first time from the animals under review, especially from India. Particular mention is made of the occurrence of *Gastrodiscus aegyptiacus* and *Pseudodiscus collinsi*, the two common parasites of horses, reported to occur also in cattle, and thus the immunity against the parasites of horses in man and other domestic animals, as was believed, [Cameron 1926] is not eternal, at any rate for these two parasites.

Fasciola hepatica is a parasite not commonly found in this country. In the area under review, only a single specimen was recovered during the entire period of the working of the scheme and is thus of a very rare occurrence in this country. The most commonly found species in India is *Fasciola gigantica*, which has recently been renamed by Varma [1953] as *Fasciola indica*. This form is more abundantly found in buffaloes and cattle than in sheep and goats in which animals it is found with moderate degree of intensity in some places. The cirrus is always armed with several rows of spines, a character which has escaped the attention of all previous workers.

Amongst the Cestodes, *Moniezia expansa* is very common and *M. benedeni* is occasional. *Avitellina* and *Stilesia* are also found with moderate degree of intensity.

Specimens of *Stephanofilaria assamensis* have been recovered, not only from the hump sore and the yoke, but also from the tail and the feet of cattle in certain parts of Assam, Bengal and Orissa, causing lesions identical to those occurring in the hump. It may be pointed out that this parasite is not found in the hilly tracts of Assam and Bengal and is absent from the Uttar Pradesh and Bihar.

Trichuris ovis and *Bunostomum trigonocephalum* are very common in sheep and goats, but cattle and buffaloes also show some infection with these parasites. *Haemonchus contortus* is very abundant, but *Gaigeria pachyscelis* is of rare occurrence in these animals. The latter parasite is not generally found in cattle and buffaloes. Oesophagostome species are commonly found in sheep and other ruminants and are reported in Tables I-IV. *Gongylonema pulchrum* is not so common.

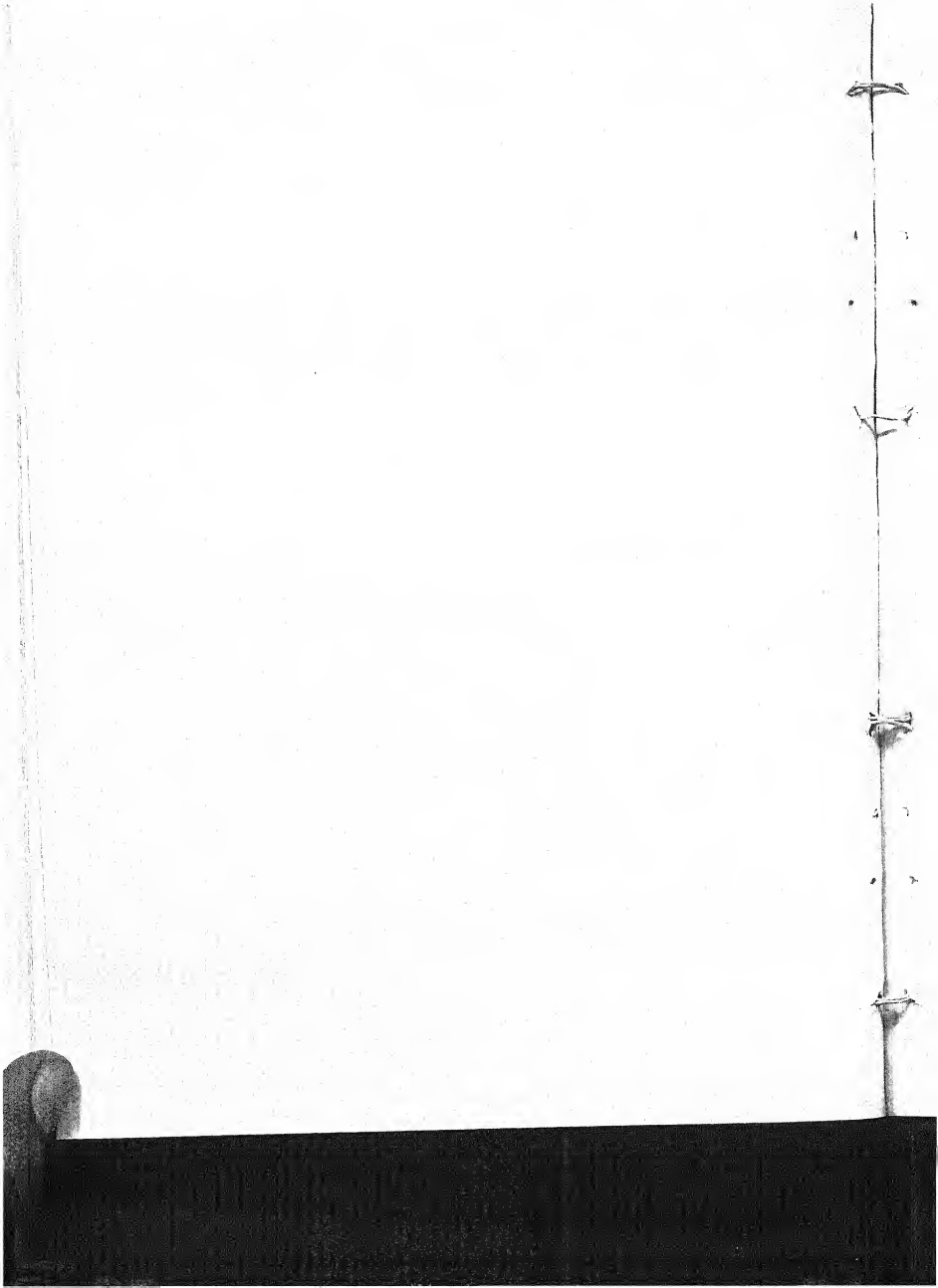
One important record, though not of helminthic origin, needs special mention, as it has not been reported so far from India. A case of *Myiasis* was caused by the occurrence of *Eristalis* larva specimens of which were referred to us by a veterinary assistant surgeon from Bengal. This is the first record of *Eristalis* larva from India.

ACKNOWLEDGMENTS

The author wishes to record his indebtedness to Sir Arthus Oliver, sometime back Animal Husbandry Commissioner with the Government of India, for the keen interest he took in the progress of this work at Lucknow. In fact, it was mainly through his efforts that the work on the Helminthic Infections in the domesticated animals was initiated in India. His successors have constantly continued to encourage the working of the scheme at Lucknow and the author offers his thanks to all of them. The author is also thankful for active help and encouragement received from Shri P. N. Nanda, the present Animal Husbandry Commissioner with the Government of India who tried to place the scheme on a permanent basis at Lucknow. The author acknowledges the help and co-operation of the Directors of Animal Husbandry of all the five provinces. The author is also thankful to the authorities of the Indian Council of Agricultural Research for the financial aid and other facilities offered in the working of this scheme at Lucknow.

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IMMUNOLOGICAL STUDIES ON *PASTEURELLA SEPTICA*

I—TRIALS ON ADJUVANT VACCINE

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(Received for publication on January 16, 1956)

PASTEURELLOSIS is to-day one of the most serious diseases of livestock especially in the countries in the East. It has been estimated that in India alone the loss due to haemorrhagic septicaemia in cattle runs annually into several lakhs of rupees and at an average more than 33,000 deaths occur each year. Besides, *Past. septica* is responsible for loss in several other species of animals, e.g. the sheep, the goat, the swine, the poultry, etc.

In endemic areas, haemorrhagic septicaemia has a seasonal incidence and generally a large number of outbreaks appear with the onset of the monsoon and winter rains. The onset of the disease is usually very sudden and the course extremely short and rapid. As such, treatment with the well-known sulpha preparations can hardly be taken up in time. Besides, the cases of the disease may be so widely scattered that it may be difficult to pay individual attention. The only practical approach in the control of haemorrhagic septicaemia, therefore, seems to be to carry out timely vaccinations in the endemic areas and to treat the sporadic cases, wherever possible, with the sulpha preparations.

For the past two or three decades, vaccinations have generally been carried out with cultures of *Past. septica* grown for 24-48 hours in nutrient broth or agar and killed by heat or chemicals like formalin, phenol, lysol, etc. These vaccines, no doubt, afford some degree of protection but the immunity has been found to be short and of a low order. A comparison of the average figures compiled by the Statistics Section of this Division, for the period from 1936-1944 and 1949-1953 will show that the extent of loss due to haemorrhagic septicaemia has not gone down appreciably although vaccinations with the commercial broth and agar-wash vaccines have been carried out intensively for the past several years Table I.

TABLE I
Showing the average annual figures for haemorrhagic septicaemia

Number of	1936-1944	1949-53
Out breaks	7,000 (about)	7,300 (about)
Animals affected	54,900 "	43,000 "
Deaths	40,000 "	33,700 "

In many endemic areas, heavy mortality continues to occur in spite of two inoculations carried out in a year and there are instances of even breakdown in immunity soon after the vaccination. In such cases plurality of strains within the species *Past. septica* was considered to be the probable cause. Investigations were, therefore, taken up at the Indian Veterinary Research Institute with a view to study the serological, biochemical and immunological differences in *Past. septica* isolated from cases of the disease in different outbreaks and from different parts of the country so as to select suitable strains for the preparation of haemorrhagic septicaemia vaccines.

Serological studies: Rao [1953] typed serologically, by agglutination and agglutination-absorption tests, 73 authentic strains of *Past. septica*. Forty-one strains included in this study were isolated from cattle, i.e. 11 from buffaloes, one from a goat, 2 from sheep, 3 from rabbits (N. C. T. C.), one from a cavy (N. C. T. C.), one from a cat, one from a pig, nine from fowls, 2 from mice and one unclassified strain (N. C. T. C.). The results of these tests confirmed the earlier observations of several workers such as Jones [1921-22], Roderick [1922], Fitch and Nelson [1923], Lal [1927], Cornelius [1929], Yusef [1935], Khalifa [1936], etc. that on serological grounds, the strains of *Past. septica* cannot be classified according to the species of animals from which they are isolated and also that there are several serological groups within the species. In this study, 6 strains were found to correspond to Group I, 4 to Group II and 12 to Group IV of Cornelius. It was interesting to observe that 30 strains belonged to one group serologically indistinguishable from the I. V. R. I. stock strain P 52. However, the possibility of these strains belonging to Group III of Cornelius could not be completely ruled out, as the Group III strain available with Rao might not have been fully antigenic for absorption tests on account of its possible change to 'R' type. The remaining strains did not fall into any of the groups tested.

On the basis of the above observations, Rao [1953] considered that the incorporation of strains representative of all the different antigenic groups was highly essential to overcome 'break-down' in the immunity produced by the present vaccines.

Biochemical studies: With a view to find out if the biochemical reactions would follow the serological differences, Rao [1953] subjected all the 73 strains to biochemical studies but did not find characters that might be considered specific for any serological grouping.

Immunological studies: Twenty seven authentic strains of *Past. septica*, 24 from the cases of haemorrhagic septicaemia in bovines and three from the cases of fowl cholera, were subjected to immunological studies by the mouse protection tests on the lines of Roberts [1947] with a view to ascertain, if, like serological groups, there also existed different immunological groups.

From these studies, it appeared that all the 24 strains from cases of haemorrhagic septicaemia in bovines belonged to one immunological group, corresponding to type I of Roberts while the three strains isolated from fowls belonged to a different immunological group(s). The immunological studies are, however, being pursued further with a larger number of strains collected from various parts of the country and specific anti-sera are being produced using formalinised as well as heat-killed antigens.

Preparation of the vaccine

(a) As the I. V. R. I. stock strain P52 which had hitherto been employed for the production of H. S. Commercial broth and agar-wash vaccines, represented the largest serological group and all the strains isolated from cases of haemorrhagic septicaemia in bovines in this country subjected to immunological study appeared to belong to one group, this strain was selected for the preparation of the vaccine in the present study.

(b) With a view to securing information on several other important points having a direct bearing on the production of a potent vaccine, investigations were carried out at the I. V. R. I. and the following data were obtained:

Rajagopalan [1942] found that (i) a suspension of *Past. septica* in a concentration of 3,000 million organisms per c.c. in 2 per cent phosphate buffer pH. 7.6 was completely sterilized when exposed for 5 minutes at 37°C to the action of the following disinfectants at the concentrations shown:

Lysol	0.11 per cent
Merthiolate	1 in 22,500.
Alcohol	12 per cent
Formalin	0.5 per cent,

(ii) that in this respect cresol and phenol were inferior to lysol. Cresol took 24 minutes at a concentration of 0.15 per cent and phenol 10 minutes at a concentration of 0.2 per cent, (iii) that carefully heat-killed (56°C for 5 minutes) unpreserved vaccine was antigenically better than heated and preserved, or a preserved vaccine, (iv) that lysol and merthiolate significantly impaired the immunogenicity of the vaccine, but alcohol and formalin did not, (v) that alcohol prevented the growth of cocci and subtilis at a concentration of 7.5 per cent but not at 5 per cent, (vi) that formalin prevented the growth of the organisms at 0.01 per cent but not at 0.001 per cent, however, growth of fungus was not prevented by formalin until a concentration of 0.5 per cent was reached, (vii) that vaccines made from broth cultures sterilised by heat (56°C for $\frac{1}{2}$ hour) or by disinfectants were inferior to vaccines of the same strength made from agar slants washed in buffer phosphate. If, however, the broth culture was washed and resuspended in phosphate buffer before sterilization, the loss in potency did not occur. It appeared that the immunizing antigens were impaired when sterilization was carried out by heat or disinfectants with the organisms in contact with foreign proteins, (viii) that it was highly important to ensure that the structure of the essential parts of the germs, particularly of their surface layers did not suffer by the treatment adopted to kill them, and (ix) that a vaccine made from a 24-hour agar culture was as potent as one of the same strength from a 6-hour agar culture.

(c) Later, during 1949-1952 experiments were undertaken with a view to explore the possibilities of evolving strains, which might be used for the production of living vaccines.

(1) *Passage of strains of Past. septica in developing chick embryo and on different media*

Three virulent strains of *Past. septica* (Past. 52, 50 and 5) were serially passaged for over two years in the developing chick embryo and on different media, viz. plain agar with different pH values, bile agar and penicillin agar in order to see if any of these treatments would reduce their virulence and render them suitable for vaccine production.

Only one strain, i.e. the bile passaged strain 'P 52' was found to lose its virulence after it had undergone as many as 384 passages but at the same time it showed evidence of loss in its antigenicity.

(2) *Passage of a strain of Past. septica through albino rats*

On lines similar to those used for the attenuation of viruses, a virulent strain of *Past. septica* was passaged in albino rats, which are normally highly resistant to this organism, in the hope that the resulting attenuated strain might prove useful in the successful vaccination of cattle against haemorrhagic septicaemia. Thirty-one serial passages were carried out by the transference of blood from one rat to another and cultures obtained at the 5th, 10th, 15th, 20th and 31st passage were tested for virulence in white rats, guinea-pigs and white mice to see if there was any evidence of attenuation. The strain was found to have assumed an enhanced virulence for rats and guinea-pigs, but no evidence of attenuation for white mice could be noticed. In view of this finding, the strain was not tested in cattle, as no appreciable change in its pathogenicity for bovines could be expected.

In view of the above findings coupled with the immunological studies, it was decided to prepare H. S. Vaccine on the following lines :

- (i) To incorporate stock strain P52 of *Past. septica* after freshly passaging it through a healthy bovine so as to ensure the full presence of capsular substance,
 - (ii) To sterilise the vaccine by the addition of 0.25 per cent formalin and
 - (iii) to add adjuvants with a view to induce maximal antibody response sustained over a long period.
- (d) Having briefly outlined the procedure for the production of vaccines, experiments were undertaken to select a suitable medium for the propagation of *Past. septica* that might yield a luxuriant growth and at the same time be economical.

Several media such as nutrient agar with 0.2 per cent buffer salts (KH_2PO_4 and Na_2HPO_4), nutrient agar containing 0.1 per cent creatinine, nutrient agar containing 0.5 per cent yeast extract, nutrient agar containing 0.5 per cent yeast extract and 0.1 per cent creatinine, nutrient agar containing 0.5 per cent yeast extract, and 0.1 per cent creatinine and $\frac{1}{2}$ to 1 per cent glucose were tried, and the growth on each medium was compared. The following medium gave the best growth at our hands and was, therefore, adopted for the manufacture of the vaccine :

Lab. Lamco.	3 gm.
Peptone Difco	3 "
Yeast Extract	1.5 "
Creatinine	0.3 "
Sodium chloride	1.5 "
Distilled water	300 ml.
Agar	9 gm.

Autoclave at 15 lb. for 30 minutes. Final pH 7.2.

(e) *Procedure for the manufacture of the vaccine*

Stock strain 52 of *Past. septica* was passaged through a bovine each time a brew of the vaccine was to be prepared. The organism was recovered from the heart blood on a blood agar plate and a single colony showing the characteristic appearance was

picked up and sown on the blood agar slants. The culture was then examined for capsulated (phase I) cells and if conforming to the desired characters, was inoculated in nutrient broth tubes, which were incubated at 37°C for 24 hours.

The roux flasks containing the yeast extract medium were seeded with the 24-hour old broth culture and incubated at 37°C for a period of 24 hours. The growth was washed with formol-saline containing 0.25 per cent formalin. The washings were diluted with the same fluid to an opacity of 6-7 of Brown's scale and the product was kept overnight in the incubator. In the later brews, however, keeping in the incubator was eliminated and the vaccine was left at room temperature.

Adjuvants were added to the bacterial suspension on the lines of Bain to give the following final product :

Bacterial suspension	15 parts
Liquid paraffin	10 parts
Anhydrous lanolin	1 part

The mixture was placed in a waring blender which was run for about five minutes. The final product was a thick white emulsion which has been found to remain stable for quite a long time. Contrary to the reports of experience of other workers in respect of the administration of such a thick vaccine, little difficulty has been encountered in drawing in a syringe as well as in injecting this product with wide-bore (16 gauge) needle. However, in winter months the vaccine had to be sucked in the syringe directly with the nozzle after pouring it in a petri dish.

(f) *Effect of cultural conditions on the growth of Past. septica*

The following observations made at the Institute are reproduced as these are of interest in the context of this work.

P 52 strain of *Past. septica* was grown on a liquid medium and it was found that (a) aeration increased the growth about four-fold, but when a stream of pure oxygen or hydrogen was passed, instead of air, nearly complete inhibition of growth occurred, (b) growth was not affected appreciably by (i) the complete removal of carbon dioxide from the environment, (ii) substitution of glucose with other common carbohydrates, or with some of the organic acids concerned with Krebs's cycle, (iii) addition of small quantities of certain hormones (thyroxine, stilboestrol, adrenaline, or insulin) and (iv) supplementation of plain broth with the common amino acids added singly.

In the routine manufacture of the adjuvant vaccine, aeration of the cultures was not carried out as the process was laborious and time-consuming, and could hardly be suitable for employing on a large scale without special apparatus. The yield of the vaccine on the yeast-extract medium even without aeration was quite satisfactory and at an average 50-60 doses were obtained from a roux flask.

Safety tests : The vaccine was tested for its safety on a very large number of cattle, buffaloes and calves under experimental as well as field conditions and was found to be quite safe. However, a small percentage of animals showed a rise of a degree or two in temperature and slight swelling at the site of inoculation, but these symptoms generally disappeared within 3 or 4 days.

Potency tests : Series of tests were carried out in cattle with several brews to determine the immunogenic properties of the vaccine. The results are presented in Table II.

TABLE II
The results of potency test

Brew No.	No. of animals in the experiment	Details of inoculation	Interval between vaccination and challenge	Challenge dose	Result	Percentage survival (vaccinated animals)	Reactions in controls	Percentage survival (Controls)	Results of bacteriological examination in animals dying after challenge		Remarks
									Vaccinated animals	Controls	
1	5	1 ml. subcut	21 days	5 million mouse M. I. D.	0/2	0		0	++	+	
		2 ml. subcut	21 days		2/2	100					
2	31	1 ml. S/C. followed with another dose of 1 ml. S/C after 12 days	1 month	do.	2/3	66.6		100	+		
			2 months	do.	3/3	100		0		++	*Recovered after showing illness.
			4 months	do.	3/3	100	*1/2	50		+	*do.
			6 months	do.	2/3	66.6	0/2	0	+	++	
			1 month	do.	3/3	100	*1/1	100			*do.
			2 months	do.	3/3	100	0/2	0		++	*do.
3	32	2 ml. intramuscularly	4 months	do.	3/3	100	*1/2	50		+	*do.
			5 months	do.	2/3	66.6	0/2	0	+	++	
			6 months	do.	2/3	66.6	0/2	0			
			12 days	5 million mouse M. I. D.	2/3	100	0/2	0		++	*do.
			4 months	do.	5/5	100	*1/2	50		+	
			5 months	50 million mouse M. I. D.	3/5	60	0/2	0	++	++	
			6 months	do.	4/5	80	0/2	0	+	++	
			8 months	do.	3/4	75	0/2	0	+	++	

TABLE II—(contd.)
The results of potency test

Brew No.	No. of animals used in the experiment	Details of inoculation	Interval between inoculation and challenge	Challenge dose	Result	Percentage survival (vaccinated animals)	Reaction in controls	Percentage survival (controls)	Results of bacteriological examination in animals dying after challenge		Remarks
									Vaccinated animals	Controls	
Brew No. 4 and 5 (Mixed)	35	(a) 2 ml. Intramuscularly	21 days	50 million mouse M. I. D.	3/5	60	0/2	0	++	++	
			2½ months		3/4	75	0/2	0	+	++	
			5 months	do.	5/5	100	0/3	0	+	++	
		(b) 4 ml. Intramuscularly	6 months	1,000 million mouse M. I. D.	3/4	75	0/2	0	+	++	
			4 months	50 million mouse M. I. D.	3/4	75	0/3	0	+	++	
6	*2	5 ml. intramuscularly	5 months	1,000 million mouse M. I. D.	4/4	100	0/2	0	+	++	
			21 days	50 million mouse M. I. D.	2/2	100					* Buffalo calves, 14 days of age, of the strain used were determined in mice. No buffalo calf was used to serve as control.
7	10	3 ml. intramuscularly	2 months	50 million mouse M. I. D.	10/10	100	0/3*	0		++	* 10 cattle vaccinated with broth vaccine challenged simultaneously all died.

NOTE. 1. Adult hill cattle have been used. Throughout the trials excepting in brew No. 6 where the animals used were buffalo calves about 1½ years in age.

2. Numerators denote survivors.

3. Denominators denote total number inoculated.

4. A 24-hour old broth culture of virulent *P. capivi* was used for challenge purpose.

Of this 1 ml. was determined to contain 100 to 1,000 million mouse M. I. D.

It will be seen from these results that under laboratory conditions the adjuvant vaccine in a dose of 2 ml. to 4 ml. intra-muscularly confers adequate immunity in cattle weighing about 250 lb. for as long as 8 months, the maximum period tested so far. It may be stated, however, that for the test carried out after 8 months after vaccination only four animals were available, three of which survived and one died thereby indicating a survival rate of 75 per cent. Further tests will be carried out in due course of time to confirm this and to find out the longest period for which animals vaccinated with this new vaccine would remain immune. The animals were subjected to a very severe challenge, the dose of the virulent culture used for the test varying from 5 million mouse M. I. D. to as high a dose as 1,000 million mouse M. I. D. The virulence of the culture was determined in white mice each time a challenge dose was to be given.

Trial on the comparative immunogenic value of the H. S. adjuvant vaccine with the routine commercial broth vaccine

With a view to compare the immunogenic properties of the adjuvant vaccine with the routine commercial broth vaccine, the following immunity trials were carried out and the results are presented in Table III.

TABLE III

Comparative immunogenic value of the adjuvant vaccine and the commercial broth vaccine

Trial No.	No. of animals used in the experiment	Details of inoculation	Interval between vaccination and challenge	Challenge dose	Result in vaccinated animals	Percentage survivals	Results of bacteriological examination in the animals dying after challenge
I	23	Adjuvant vaccine 2 ml. intramuscularly	2½ months	50 million mouse M. I. D.	2	75	+
		Commercial broth vaccine 5 ml. S/C	21 days	Do.	1	25	+++
		Unvaccinated controls	—	Do.	0/2	0	++
		Adjuvant vaccine 2 ml. intramuscularly	5 months	50 million mouse M. I. D.	5/5	100	
		Commercial broth vaccine 5 ml. S/C	3 months and 6 days	50 million mouse M. I. D.	0/4	0	++++
		Unvaccinated controls	—	Do.	0/3	0	+++
II	23	Adjuvant vaccine 2 ml. intramuscularly	2 months	50 million mouse M. I. D.	10/10	100	
		Commercial broth vaccine 5 ml. S/C	Do.	Do.	0/10	0	+++++
		Unvaccinated controls	—	Do.	0/3	0	+++

NOTE. Numerators denote survivals. Denominators denote total number inoculated.

+ = Positive for *Past. septica* on bacteriological examination.

A 24-hour old broth culture of virulent *P. septica* was used for challenge purpose. Of this 1 ml. was determined to contain 1,000 million mouse M. I. D.

*Nine animals were vaccinated with adjuvant vaccine and another group of 9 animals with commercial broth vaccine. Five animals were used as control. One animal of the broth vaccine group was not available for challenge.

These results clearly show that the adjuvant vaccine is far superior to the routine commercial broth vaccine. It will be seen that in trial No. 1 in the case of adjuvant vaccine, the interval between vaccination and challenge was 2½ months and 5 months as compared to 21 days, and 3 months and 6 days respectively in the case of broth vaccine. Thus, the broth vaccine was at an advantage at the time of challenge. The experiment was planned in this manner, as it was considered that the broth vaccine was not likely to confer a lasting immunity, and the data obtained would be more conclusive if the adjuvant vaccine was found superior even when kept at a disadvantage.

Trial on the comparative immunogenic value of the adjuvant vaccine and Bain's vaccine with the commercial broth vaccine

During May, 1955, a consignment of Bain's adjuvant vaccines was received at this Institute for carrying out trials in regard to its safety and potency, for Indian cattle and buffaloes and in order to determine its efficacy as a prophylactic against haemorrhagic septicaemia in this country. This vaccine was found to be quite safe for cattle and buffaloes as well as for young calves and to possess quite good immunizing properties. Opportunity was availed to carry out tests with the Bain's vaccine and the adjuvant vaccine under study at this Institute to find out the comparative efficacy of the two products in relation to the old broth vaccine.

The results are presented in Tables IV and V on the basis of trials in white mice and cattle respectively.

Trial on mice

Three groups each of 10 white mice were vaccinated with the three vaccines and five mice were left unvaccinated to serve as controls. All the surviving mice were challenged with a virulent culture of *Past. septica* after 21 days of vaccination. The results are set out in Table IV.

TABLE IV

Comparative immunogenic value of the Bain's vaccine and the adjuvant vaccine with the commercial broth vaccine

No. of mice	Details of inoculation	Interval between vaccination and challenge	Challenge dose	Result	Percentage survival	Result of bacteriological examination in the animals dying after challenge
35	0.25 ml. intramuscularly (Bain's vaccine)	21 days	100 M.I.D.	4/5	80	+
	0.25 ml. adjuvant vaccine	do.	do.	6/8	75	++
	Commercial broth vaccine 0.5 ml. S/C	do.	do.	2/8	25	+++++
	Unvaccinated controls	—	do.	0/5	0	+++++

NOTE. Numerators denote survivals. Denominators denote total number inoculated.

+ = Positive for *P. septica* on bacteriological examination.

A 24-hour old broth culture of virulent *P. septica* was used for challenge purpose. Of this 1 ml. was determined to contain 1,000 million mouse M. I. D.

Ten mice were inoculated with each vaccine but a few died of miscellaneous causes before challenge.

Trial on cattle

On the basis of age, weight, etc. 30 hill cattle were divided into three equal groups of 10 animals and each group was vaccinated with one of the three vaccines. Besides, a fourth group of three animals was left unvaccinated to serve as controls. These controls were so selected as to represent all the three different age and weight groups of the vaccinated lots. After two months of vaccination, all the animals were challenged with $\frac{1}{2}$ ml. of 10-1 of 24-hours broth culture of virulent *Past. septica* equivalent to 50 million mouse M. I. D. The results are presented in Table V.

TABLE V

Comparative immunogenic value of the Bain's vaccine and the adjuvant vaccine with the commercial broth vaccine

No. of animals	Details of inoculation	Interval between vaccination and challenge	Challenge dose	Result	Percentage survival	Result of bacteriological examination in animals dying after challenge
0	3 ml. intramuscularly (Bain's)	2 months	50 million mouse M. I. D.	10/10	100	
10	3 ml. intramuscularly adjuvant vaccine	2 months	50 million mouse M. I. D.	10/10	100	
10	5 ml. subcutaneously Commercial broth vaccine	do.	do.	0/10	0	+++++
3	Unvaccinated	do.	do.	0/3	0	+++

NOTE. Numerators denote survivals. Denominators denote total number inoculated.

+ = Positive for *P. septica* on bacteriological examination.

A 24-hour old broth culture of virulent *P. septica* was used for challenge purpose. Of this 1 ml. was determined to contain 1,000 million mouse M. I. D.

The results in mice as well as in cattle clearly indicate that the adjuvant vaccine under study is as good as the Bain's vaccine in its immunizing properties, and that both the vaccines are far superior to the routine commercial broth vaccine.

Field trials

Three dairy farms having the history of annual recurrence of haemorrhagic septicaemia were selected for this study. In two farms, 699 animals were vaccinated with the adjuvant vaccine and the remaining stock numbering 463 with the commercial broth vaccine. At the third farm, 985 animals were vaccinated with the adjuvant vaccine, 891 with the Bain's vaccine and the remaining stock numbering over 15,000 with the commercial broth vaccine.

At one of the farms, the records of milk yield in respect of 166 buffaloes and 17 cows vaccinated with the adjuvant vaccine were compared with those of the milk yield of 93 buffaloes and 16 cows vaccinated with the broth vaccine. It was found that in both the groups there was an average fall in milk yield of about 0.8 to 1 lb. per animal for three days following vaccination and thereafter the milk yield returned to normal. This slight decrease in the milk yield is attributed to the interference with the daily routine of the animals including handling and confinement to the stalls during this period.

In the field trials, it could neither be possible to leave a few animals unvaccinated to serve as controls nor to subject a few representative animals of each of the vaccinated groups to an experimental challenge with a virulent culture, as the farm authorities were not prepared to take the risk involved. However, it is hoped that by comparing the figures of mortality due to haemorrhagic septicaemia in the different groups and also the death rate in the group of the animals vaccinated with the adjuvant vaccine with the average mortality figures of the past few years, some useful data regarding the efficacy of the vaccine under study will become available in due course of time.

SUMMARY

1. The evolution of an adjuvant vaccine against haemorrhagic septicaemia is reported.
2. Large scale field and laboratory trials have shown that the vaccine is quite safe for cattle and buffaloes of all ages.
3. Tests have indicated that the immunity conferred by the administration of the vaccine is lasting for at least eight months against a heavy challenge with virulent *P. septica*. The results in respect of 8-month period, however, require to be confirmed on a larger number of animals as only four animals were used for challenge of which 3 (75 per cent) survived.
4. On comparative trials, this vaccine has been found to be definitely superior in its immunising properties to the commercial broth vaccine at present issued from the Institute.

ACKNOWLEDGMENT

The authors are thankful to M/s. T. P. Banerjee, P. Chandra Sakariah and M. S. Sethi for technical assistance and to Shri S. Sen for compiling the figures given in Table I. They also thank Brigadier H. L. Bhandari, Col. Nayyar and Capt. W. H. Dean of the Remount, Veterinary and Farms Corps, Mr. D. N. Khurody, Milk Commissioner, Bombay and M/s. M. R. Marathe and N. R. Adker of the Aarey Milk Colony for their co-operation in field trials.

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ABSTRACTS

A comparison of the intradermal and subcutaneous routes in producing immunity to brucellosis in cattle. McDIARMID A. (1954). *J. Comp. path.* **64**, 384-91

THE author has compared the results of immunity produced in groups of ten heifers vaccinated with 'Cotton strain 19' at the dose-rate of 0.2 ml. intradermally, 0.2 ml. subcutaneously and 5.0 ml. subcutaneously. A batch of ten unvaccinated heifers was kept as controls. All the heifers were obtained from a non-vaccinated brucellosis-free herd. At the time of vaccination they were in calf for two months and negative to agglutination test for brucellosis. The reaction after vaccination by intradermal route was the production of a small local necrotic lesion which rapidly healed. Whereas slight oedematous area was observed in 0.2 ml. subcutaneous dose, 5.0 ml. dose exhibited usual systemic and local reactions. Serum samples from vaccinated heifers were tested for agglutinins from time to time. After three months of vaccination, all the animals were challenged by instilling into conjunctival sac 1 ml. of virulent *Brucella abortus* strain 544 containing 134 million live organisms. At parturition, serum titre was recorded and cotyledon foetal stomach-contents, colostrum, milk samples were examined culturally and biologically. The number of calves that were born full-term and survived after challenge in 0.2 ml. intradermal group, 0.2 ml. subcutaneous group and 5.0 ml. subcutaneous group was 6, 7 and 7 respectively, while in the unvaccinated controls all the calves were born dead. The immunity produced by 0.2 ml. intradermally was found to be equal to that obtained by the same quantity of vaccine given subcutaneously. However, in both of the 0.2 ml. groups and in the group vaccinated with 5.0 ml., the level of immunity was poor since 5 out of 10 animals were found infected in each group after challenge. These results are at variance with the previous findings of the author. The factor or factors responsible for such discrepancies are not known, but in the opinion of the author the possibilities are (a) that a pregnant heifer does not respond so well to the *Brucella abortus* antigen as does the non-pregnant heifer and (b) the short interval between immunization and challenge. The mode of administration of a correct challenge dose requires careful consideration whenever such immunity experiment are performed. The author affirms that vaccination of pregnant cattle with strain 19 vaccine can be carried out without any risk of abortion. The finding is of great importance when dealing with an abortion storm in a non-vaccinated herd (P.C.).

Antibiotics and nitrogen utilization in growing cockerels. R. H. THAYER AND V. G. HELLER (1955). *Poult. Sci.*, Vol. 34, No. 1, pp. 97-102.

EXPERIMENTS were carried out to determine the relative efficiency of protein utilization between antibiotic and non-antibiotic for chicks using both growth response and nitrogen balance techniques. The study consisted of four feeding

trials conducted in battery brooders with the basal diet supplemented with 20 mg. per lb. of either procaine penicillin or aureomycin hydrochloride. The length of the feeding period varied from 27 to 33 days in the different trials. The nitrogen balance study was carried out with four-week old cockerels to determine the effect of penicillin and aureomycin upon dietary nitrogen utilization.

It was observed that the net result of antibiotic feeding was to produce greater growth and more efficient feed conversion. The results indicated that penicillin and aureomycin brought about an increase in the amount of dietary nitrogen which was digested and absorbed from the digestive tract of the four-week old cockerels. A possible explanation is that the rate of digestion may have in some way been increased. The antibiotics may have reduced the number or type of competitive intestinal bacteria which used amino-acids as they were released in the digestion process. The data indicate that the increased growth response due to the addition of antibiotics to rations for chickens may be due to an increased efficiency in the digestion and absorption of dietary nitrogen. (S. B.).

The effect of sexual stimulation prior to service on the behaviour and conception rate. B. M. KERRISH. *Brit. J. Anim. Behaviour*. Vol. III, No. 4, pages 125-130.

IN this article the author has mentioned the behaviour of an experienced bull running with the herd at precoital, coital and postcoital state. He has also mentioned the behaviour of bulls due to incomplete sexual stimulation under conditions of controlled mating and collection of semen by artificial vagina. Sex drive and vigour of the ejaculatory reflex are significantly lowered in following the rigid routine of controlled mating in most artificial insemination centres and farms. The bulls fail to get sufficient precoital excitement, which probably not only affect sexual organs but also plays a part in promoting the general metabolism of the body through the levels of secretion of endocrine glands, thus increasing the excitability and tone of the whole body in giving a vigorous and better co-ordinated ejaculation.

The experiments revealed a significant rise in conception rate with increase in precoital stimulation. Animals not getting sufficient excitement prior to coitus appear to be disinterested and unresponsive to service and do not give collection readily. The fall in conception rate may be due to the poor quality of semen produced. (D. P. M.).

Familial resistance to Newcastle disease in strain of New Hampshires. FRANCIS, D. W. and A. F. KISH (1955). *Poult. Sci.* 34, 2, 331-336.

IN this paper an attempt has been made to determine genetic differences among six family lines of New Hampshire chickens in respect of resistance to a standard challenge dose (LD 50) of Newcastle disease virus. Birds used in mating to raise chicks for challenge were selected from different families having mortality varying from 3 per cent to 17 per cent. The family differences in mortality rate following the challenge were used to evaluate the degree of resistance.

A difference in mortality following challenge dose of virus was seen between lines from the various matings. The line raised from the family with the highest pre-challenge mortality showed a most rapid increase in deaths as compared with the line from the low-mortality-rate family. Great differences in the percentage of mortality were shown to occur between chicks challenged in warm battery room and those challenged under brooder-house conditions. There was 31 per cent mortality in the former case and 88.5 per cent to 96.6 per cent in the latter.

To explain family differences in mortality following challenge with a standard dose of virus, the possibility of existence of a specific mechanism in either aiding or preventing the transport of virus in which red cells appear to play some role, has been suggested. (C. R.).

On the invasion of the central nervous system by nematodes—I. The incidence and pathological significance of nematodes in the central nervous system. SPRENT, J. F. A. (1955). *Parasitology*, 45 (1, 2): 31-40.

THE author reviews the available literature dealing with the incidence of nematodes in the central nervous system and discusses the pathological significance of nematode infection in relation to the central nervous system.

A wide variety of nematode species like ascarids, filariids and strongyles, particularly their larval and immature stages, are known to invade the tissue of the brain and spinal cord as well as the meningeal spaces of animals and human beings, some manifesting violent nervous symptoms while others apparently producing no symptoms at all. The direct pathological changes resulting from invasion of the central nervous system are probably due to the traumatic effect of the nematode parasite, and are found to vary in their extent and nature, depending upon the size, the route of migration and the activity of the species involved. The relatively small larvae of *Toxocara* sp. may wander in the brain without producing sufficient damage to provoke symptoms, while larger larvae such as those of *Ascaris* spp. and filariids do sufficient damage during their migrations to cause definite derangement of the central nervous system. The pathological changes, which may or may not be seen in close association with the invading organism, may be diffused or focal, and may include haemorrhage, degenerative changes, cellular infiltration and glial proliferation. Nematodes entering the meningeal spaces may cause severe nervous symptoms by compression of the spinal cord, by distension and thrombosis of blood vessels of the spinal cord, by destruction of the meninges, or by meningeal haemorrhage.

Nervous symptoms are also found to be associated with nematode infections outside the central nervous system where there is no evidence that the parasite had invaded the central nervous system and where the symptoms tend to disappear after anthelmintic treatment. The occurrence of toxins in such infections offers no satisfactory explanation for the nervous symptoms while there is experimental evidence to prove that the pathogenesis may be allergic in origin.

The possibility that the nematodes entering the central nervous system may carry viruses present in the other parts of the host's body, thus facilitating a secondary invasion of the central nervous system, is also discussed. (C. T. P.).

Studies on the productive value of roughages and concentrates for lactation. J. K. LOOSLI, R. F. DAVIS and R. G. WARNER (1955). *J. Dairy Sci.* 38, 797-804.

THE consistent increase in milk yield when concentrates were used to replace part of the hay on an equal T. D. N. basis is to evidence that the T. D. N. system does not accurately evaluate these two feed sources for milk production. This has been interpreted by some workers as indication that concentrates contain a specific unidentified factor(s) which stimulates lactation; while others have attributed the observed increase in milk production to an increase in the estimated net energy (ENE) intake on rations containing concentrates. To test the validity of the one or the other of the two postulates above, the present authors undertook reversible type experiments with 25 lactating cows; the basis of replacement was either equal TDN or equal ENE. They found that when the replacement was made on the basis of equal TDN (but more ENE) there was a considerably greater increase in milk production than when the replacement was made on the basis of equal ENE (but less TDN). Thus, cows, on an average, produced 2.5 lb. more FCN per head per day when 10.2 lb. hay was replaced by 6.8 lb. concentrates containing almost equal TDN (but more ENE). Replacing hay with concentrates according to the ENE system resulted, in an average, increase of 0.8 lb. FCN per head per day on the same ENE intake but less TDN. The significantly greater milk yield from the TDN above the ENE feeding system, the authors state, shows rather conclusively that Morrison's ENE values more accurately estimate the comparative productive usefulness of the energy in the roughages and concentrates studied than do the TDN values. Even ENE appeared to slightly overrate the value of roughages in comparison to concentrates for lactation, but to a much lesser degree than TDN. The data presented, the authors conclude, disprove the lactation factor theory, which assumes the presence in concentrates of some specific unidentified factor(s) stimulating lactation. (B. N. M.).

Beta-propiolactone as virus altering agent for New Castle Disease vaccine. WALTER N. MACH and ACHIT CHOTISEN, (1955). *Poultry Sci.* 34, 1010-1013.

THE authors describe a Newcastle disease (Ranikhet disease) vaccine produced through chemical alternation of its pathogenicity.

The virus was isolated from a recent clinical case, and propagated in the allantoic fluid of embryonating chicken eggs. It was then treated with 0.025 per cent beta-propiolactone and incubated for two hours at 37°C. The vaccine so produced was injected intra-muscularly in doses varying from 0.5 ml. to 2 ml. into 43 ten-month old white Leghorn chickens of a disease-free flock. On the 16th day heart-blood from the vaccinated birds was collected to determine antibody titres, and all the vaccinated birds and controls were challenged with 0.2 ml. of virulent virus. Vaccinated birds did not show any disease symptoms, but 97.4 per cent of the controls got the infection and 84.6 per cent died. The agglutination inhibition titre in the pre-vaccination serum was 1:10 while it rose to 1:320 or higher in the post-vaccination samples.

Further trials with this method of preparing a vaccine are considered advisable as the risk of introducing the infection which accompanies the use of attenuated virus vaccine is avoided here.

MGIPC—M—31 AR/56—9-3-57—1,000.



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